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VORTEX RINGS OF LIQUIDS AND GASES.

EVERY one has seen skillful smokers eject from their mouth or from their pipe those beautiful white wreaths

FIG. 1.—WREATHS OF TOBACCO SMOKE.
(From the painting by Brauwer, in the Lacaze Gallery at the Louvre.)

whose vaporous curlings in the still air are watched with such delight; and it is a fact of daily observation that a drop of soapy water dripping from the end of the finger spreads out in the washbowl into the form of a perfect ring which slowly increases in size as it sinks to the bottom.

Why do light particles, instead of freely diffusing themselves in the liquid or gaseous medium, take this special state of mobile equilibrium and regular grouping? Why this form, so fragile in appearance, instead of some other more simple and perhaps more stable? Is it a result of pure accident or pure design? If the latter, what can be the secret of it? It will not be difficult to divine it shortly, and a few words will suffice for the present to show that we have here not a rare and exceptional fact, but a very general law of nature, common examples of which are right before our eyes.

Ever since the invention of firearms similar wreaths have been observed to sometimes follow the firing of a gun, and to form by their slow aerial ascent a contrast with the deadly velocity of the projectiles. In port, it augurs well to the sailor when he sees, instead of a long cloud of smoke from the chimney of the departing steamer, a few large rings mount straight upward. But the omen may be deceptive, for I have myself once seen, through the strong draught created by an express train, the smoke from the locomotive entirely formed of vertical rings which the current of air had turned up in this direction without breaking them. Whoever has gone through a course in chemistry must certainly have guarded in his memory that beautiful experiment in which the bubbles of phosphureted hydrogen given off by a mixture of phosphorus and an alkaline hydrate, or more simply by throwing into water a fragment of phosphuret of calcium, take fire spontaneously on the surface of the water and produce magnificent rings of white smoke, the regular ascent of which, with ever-increasing diameter, may be rendered still more striking by the incandescence of a few bubbles in contact with pure oxygen. Nature herself, outside of all human intervention, takes delight in assembling and putting in play at times, in the incessant ardor of her work of life and death, all the elements of this curious chemical reaction; and it is then that we see, during warm summer evenings, rising over the stagnant water of marshes, those ignes-fatui to which the Middle Ages attached so poetic legends. On a scale more grand, the craters of volcanoes at times perform the office of our firearms; and it was only quite recently that Mr. Faye, after many other observers, entertained the Academy on the subject of the magnificent annular clouds that are seen over Vesuvius on certain days.

In the heavens, on the extreme confines of our planetary system, Huyghens, with the first improvements of the astronomical telescope, ascertained the annular form of those curious satellites of Saturn which Galileo had likened in some sort to handles; while even to-day their singular equilibrium is yet being discussed. All around the earth the November asteroids, with their so marked periodicity of thirty-three to thirty-four years, seem to form a veritable crown of planetary *débris*, and everything appears to prove that the Milky Way itself is nothing else than a gigantic ring of cosmic dust of which our sun and all its satellites are merely a few grains. The question of form, as concerns the beautiful meteor of the zodiacal light, is almost beyond doubt; and finally, among those incipient worlds that we call nebulæ, we find again the annular configuration with such frequency that we can absolutely no longer consider it as exceptional. The spot between β and γ of the Lyre, alongside of brilliant Vega, is always cited, as is another similar one between the Swan and the Fox, and a third in Ophiucus, and an oval with two nuclei near the triple star γ of Andromeda; and Lord Rosse, with his great telescope, has shown that many of the nebulæ which Herschel has called "planetary" are in reality only rings with one or two central stars. There are others still in the Greyhounds and in the Virgin, on the borders of the Great Bear, of Bootes, and of Pegasus and of the Lion, which seem to exhibit all the passages between the spiral vortex and the perfect ring. Others are veritable broken rings, and no one is astonished to-day at the inspiration of genius which caused La Place to see in the fragmentation of such rings the entire birth of our solar system.

FIG. 2.—FORMS OF A COLORED DROP ENTERING A COLORLESS LIQUID.

But, again, it is often in the infinitely small that the laws of nature reveal themselves best; and it was, in reality, upon the filiform currents produced by the osmotic exchange of two liquids through the pores of a membrane that I made the first observations from whence a new study was to arise. Watching intimately the curious phenomenon with which Dutrochet, when he had discovered it, wished to connect all the laws of life, I taxed my ingenuity to catch in the act, so to speak, the very current of osmosis. With alcohol and water the thing is not easy; but on carefully profiting by all the plays of refraction and by the magnification of cylindrical glasses, we may nevertheless succeed in distinguishing against certain grounds—either very black or highly illuminated—delicate and brilliant lines which are indicative of the motion. And then it becomes a truly curious phenomenon to see two liquids so full of affinity for each other, when brought into intimate contact through a permeable membrane, obey, almost without mixing, the laws of gravity, and begin their movement one through the other in the form of very distinct filaments, which exhibit at once the clearness and apparent fixedness of a thread of pure crystal.

Let us say, in passing, that we have here what mathematicians have decorated with the grave names of: *discontinuous motion* on the one hand, in the sense that there is a clear separation, without gradation of velocity, between the mobile vein and its liquid envelope; *stationary or permanent motion*, on the other hand, in the sense that the fluid particles replace one another, at every point of space, always with the same velocities and the same directions, their general appearance being that of a continuous whole, endowed with one at least of the properties of solids, a *definite* figure.

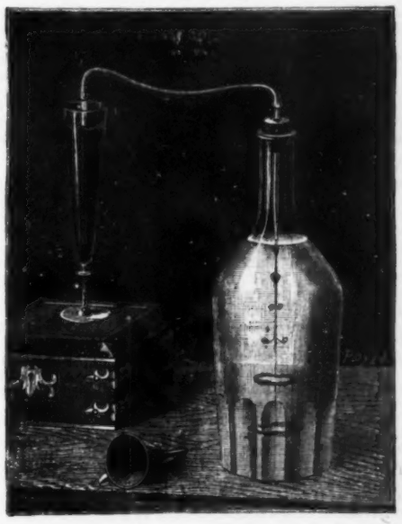


FIG. 3.—APPARATUS FOR STUDYING THE VORTEX RINGS OF LIQUIDS.

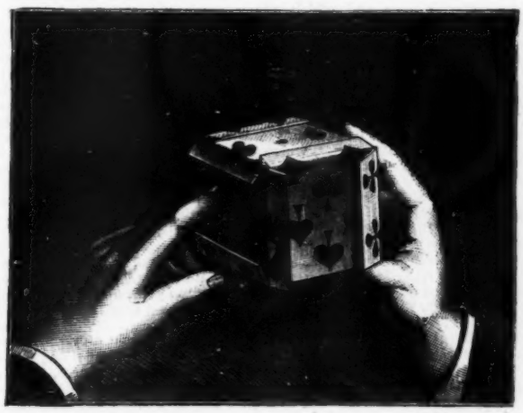


FIG. 5.—BOX MADE OF PLAYING CARDS FOR MAKING RINGS FROM TOBACCO SMOKE.

But in the majority of instances this figure is not absolutely fixed, and the movement, without ceasing to be permanent, exhibits regular *periods*, that is to say, the delicate filament, while keeping its individuality, does not seem rigid, but shows under the influence of the pulsative and isochronous movements which appear to exist in the very essence of osmosis, alternate dwellings and contractions which give, at a certain distance, the impression of superposed shafts of pillars, capitals of larger and larger size, pointed parasols, and Chinese hats with several crowns. If we look downward we soon discover in these volutes and other forms the profiles of true circular rings, scarcely attached by an invisible web to a central rod which carries them along in groups of two or three that are endowed with peculiar movements. A section of the vein along its axis of revolution gives the outline shown at A, Fig. 2, and there occurs at once to our mind a simpler and easier mode of experimenting to discover the elementary law of this phenomenon which is so curious in its geometrical regularity.

The superposed forms of figure A are evidently only the successive phases of a same small drop emitted at every pulsation, and all our efforts must tend toward isolating and rendering slower, while at the same time making more visible, these different aspects. This last point is the most

FIG. 4.—ARRANGEMENT OF LAMP CHIMNEY FOR EXHIBITING RINGS OF SMOKE.

easy to effect. Without recurring to the well marked precipitates that are given by certain chemical reactions, we may find in tinctures of aniline, blue especially, resources that are almost unlimited. Outside the laboratory, the color box, the ink bottle, coffee, and wine, and, better still, soap water, will suffice for all our experiments. With a drop of alcohol or a trace of glycerine or of sugar, we have it in our power to insensibly modify the density of liquids and to reduce the action of gravity to a minimum in having at pleasure ascending or descending veins. The latter are usually the easiest to obtain, in that the free surface of a liquid is always more easy of access than the lower portion. Fig. 3 shows a very simple arrangement, and one that explains itself. Owing to the properties of the siphon which the rubber tube forms, it is evident that we have only to raise the level of the colored liquid in the glass to obtain the flow that we may wish. However, certain practical difficulties of manipulation, along with others inherent to the superficial properties of liquids, will cause a preference, in exact experiments, for a system of communicating vessels. Such a system may be easily arranged as follows: An ordinary lamp chimney makes an excellent vessel if one end be closed by a cork traversed by a tube, the latter being put in communication with the bottom of another like vessel by means of rubber tubing, or with the tube of a vertical funnel that may be either fixed or movable according to the kind of supports that one may have at his disposal.

A ligature on the tubing, or a pinch-cock, in lieu of a stopcock, is all that is necessary to regulate to any degree of speed the outflow of the colored liquid. Care should be taken to have this colored liquid a little, but not very much, less dense than the other. One more device will do away with the necessity of changing the level of the vessels, and this consists in confining a little air over the surface of the liquid by means of a piece of bladder, so that the least pressure on the latter will give either a quick or slow outflow as may be desired.

With a system of this kind, sufficient precision may be attained without the use of capillary orifices, such as a piece of thermometer tube or a glass tube drawn out to a fine point, which are not always at hand; because, with a little ingenuity, there may be substituted for these the quill of the feather of a small bird, a small straw, or, what is an excellent idea, a pinhole in a piece of bladder stretched over the end of a tube. Let us change the microscopic hole into a circular aperture one to several millimeters in diameter, and we shall see develop themselves in all their beauty those details which are so difficult to ascertain in the microscopic jets of osmosis.

After carefully establishing the surface of separation of the two liquids at the level of the orifice, let us exert a very slight pressure, and we shall see at first issue, at the end of a short and thick stem, a sort of convex toadstool (Fig. 2, C, 1), upon whose margin there immediately exhibits itself a revolution backward—evidently indicating a resistance and friction of the ambient mass. It seems that the latter, forced from in front, gives it passage only to resume at once the positions lost, with a sort of local inertia and elasticity which cause it to immediately close upon itself. Hence the appearance of thrust or compression in front and of pull or dilatation behind, and of very pronounced sliding at the sides, which, at the expense of the original impulsion, give rise in the little mass to very peculiar movements *in situ*. Scarcely detached from the tube, the drop is seen to widen on its stem and to become hollowed out beneath (Fig. 2, C, 2); its edges turn inward and soon begin a re-entrant rolling movement, which seems to attract to it, as if by suction, the tail of the colored filament (C, 3). Once started, this gyratory motion is kept up continuously by the friction, which, on the external contours, is all the time destroying a little of the velocity acquired. The whole substance of the drop must pass therein, and, with it, numerous molecules of colorless liquid whose interposed layers will serve as support to the geometrical inrolling of spirals that are continuously increasing in size. It is truly an endless rolling-up, a stretching out in surface, of the entire little liquid mass; so that in the end (C, 4) the front line is made up of an infinitely thin tissue which will finally break through the stress of tension of the whole circumference. And now we see that curious form (C, 5) of mobile equilibrium of which so many examples have struck us, and the anatomy of which, in some sort, as well as the genesis, we have just given. These crowns, which are so singular, have a structure which is yet more curious than we had supposed. They are not solid rings, nor even simple hollow rings such as we might make by uniting the ends of a piece of rubber tubing; but, to understand how they are formed, we must imagine a continuous collar of watch springs pressed against each other along a circle which shall unite their extremities, or, to speak geometrically, the figure that a plane spiral would engender in revolving around an asymptotic axis.

Observation discloses in these forms transparencies and delicate lines that it would be impossible to reproduce. Light horizontal striæ run from one volute to another, and mark with surprising delicacy the number and distance apart of the rolls. There are other effects of exquisite beauty which it is a pleasure to produce directly in water without passing through these intermediate phases. For this purpose the apparatus may now be simplified by tying a piece of membrane over the bottom of the tube, and for an orifice using an aperture pierced in a thin piece of cork, which is introduced into the middle of the tube and fitted with sufficient accuracy to make its edges watertight. In spite of some difficulties connected with filling it, we have thus a very practical instrument, and the first satisfaction that it gives is that of showing at each expulsion of the colored ring, by pressing the membranous bottom, a corresponding entrance, in a contrary direction, of a sort of negative ring, which descends as a clear object into the body of the dark liquid, or *vice versa* if it is the upper compartment that has been tinged with a few drops of colored alcohol to facilitate the maneuver. We may, moreover, have the same thing with smoke, as shown in Fig. 4.

Better still, we may do without any apparatus in letting fall vertically from a height of two or three centimeters at the most a slightly colored drop into a colorless mass in a state of rest. Experiment had made known to all chemists, long before Trowbridge of America gave the theoretical reason of it, the necessity of employing liquids that differ but slightly, or, at the very least, those which are readily diffusible in one another. However, Reusch, a German observer, has described rings (very unstable, it is true) of oil in water, and which were produced by the aid of an apparatus on the same principle as ours.

What is certain and very interesting from the standpoint of the cosmical examples that we have cited is that, after substituting water for oil in the upper compartment, every pressure was seen to detach from the sides of the drop tube myriads of little oily drops whose impulsion rendered visible in the interior of the clear water the annular structure of the vortex formed by the irruption of a mass of liquid which was absolutely identical. The fact in its generality may be verified with a milky emulsion of ginger or with a few superficial particles of dust, and it is also observable by the method of shadows, these being thrown upon a highly illuminated white porcelain plate.

It is not only of the study of veins that cannot be made without apparatus that I speak; almost imperceptible grains of coloring matter, thrown on the surface of water, very quickly give rise to fine, descending threads which often permit us to observe in the phenomena of solution the same character of intermission and discontinuity that we have just pointed out in those of osmosis. A pen full of ink, a bit of sugar caused to melt, and a thousand other trifling means present themselves to the mind. A piece of thread hanging from a glass filled above the edge makes an excellent capillary siphon and permits of obtaining, without its being touched, a most perfect continuous flow—so perfect, indeed, that unless the surface of the water be disturbed or the glass shaken, there will be obtained filaments of wonderful stability, which, after the first spreading out that seems to open a way for them, uniformly follow their course without the least pulsation to betray their internal movement. So appear in the calm of the flat desert those very straight columns of smoke that are seen in Guillaumet's painting in the Louvre. So, again, a flexible thread carried along by a parachute is distorted without being broken by the wind. The straight line seems no longer a necessary direction; and, provided that the liquid exhibits from top to bottom continuous variations in density, such as are produced by inequalities of temperature or of concentration, the filament invariably takes the form of a lengthened spiral with broader and broader and closer and closer curves that are always terminated and often surrounded by the compact revolutions of a superb helicoidal figure having the aspect of exotic foliage or of rich florescence, and which was first seen and described by Prof. Tito Martini, of Venice.

It is no longer a question here of fleeting and delicate phenomena, but of appearances which are capable of lasting with remarkable stability for several entire days, while it is with difficulty that our rings last for a few instants. If these latter appear, in fact, to exhibit when in motion a true elasticity of form, it never happens that they are found to outlive the loss of their first impulsion. Almost always, from the first, there are seen to take rise in their interior a few denser nuclei, which take the advance of the rest of the mass and descend as if suspended from elastic arches whose long branches they draw out to a greater and greater length (Fig. 2, B). Each of them seems to undergo in its interior the different transformations shown in Fig. C, until there is produced a small secondary ring, which now remains hooked to its two handles, and now ends by detaching itself or by dividing itself up into several others that are finally seen, if they are sufficiently small, to stop at that point and remain for a long time in the midst of the quiet liquid.

All these little rings, with the curved filaments which support them, form a very marked figure in the water—a sort of diadem whose original outline almost always, at the first sight, causes a neglect of certain less visible details wherein the true mechanism of the phenomenon is revealed. It is necessary to employ a very brilliant light and to observe against a white background if aniline blue is used, and against a black background if soap water is used, in order to discover between all these arches the delicate tissue which connects them, and which, rising much above the place where the ring was seen to break, produces the curious aspect of a fantastic hydra or diaphanous form that we have endeavored to reproduce in Fig. 2, B.* Let us repeat then, with our drops, the experiments as often as we will and this is what we shall very distinctly see: So long as this toad-stool-like form, with involute margin, of which we have spoken, advances in the water, the surrounding liquid being repelled in front is constantly drawn in behind to be swallowed up in the volutes, which, however, it cannot increase indefinitely.

This does not happen, moreover, without a very marked elastic reaction; and, at the moment when the almost entire substance of the drop has passed from the axis to the margin—at the moment when the center finally becomes too weak—when the thin tissue ruptures, the water rushes upward through the breach, and, after a half revolution, seizing the free edge of the scroll, carries it along and tears it, while the other end of the spring, now at too great a tension, unrolls in the opposite direction, or breaks and sends downward long, irregular tentacles.

Rings of smoke attain, without breaking, much greater dimensions. By evolving vapors from phosphoric acid or from hydrochlorate of ammonia, or smoke from any source, in the interior of a large perforated box, one of whose sides consists of a bent sheet of metal, we may by a blow with the hand eject to several feet distant rings several inches in diameter, which permit all the details of structure of liquid rings to be seen, and which are very convenient for exhibiting to an entire lecture room the difference in velocity of the propagation of sound and of the concussion of air which gave rise to it. A soap bubble filled with smoke produces, when collapsed, effects of the same nature; and, finally, a box made of playing cards such as all children know how to construct (Fig. 5) permits of a complete study, with the help of tobacco smoke, of the slight influence of the form of the aperture on the rings which are caused by slight taps to issue through the very orifice by means of which the box was filled.

The orifice may be changed to a square or even to a rectangle: at the very most, certain combinations of elongated slits or of multiple holes will produce those composite forms to which a profound study of the English physicist, Thomson, has given so great an importance under the name of vibrating rings.

If we eject two rings, one after the other, we see that they always tend to overtake and traverse one another alternately by a very curious play of successive accelerations and contractions. But this does not always happen without some reciprocal damage if the rings are somewhat large, and it is really only upon the delicate liquid filaments of our first study that we can verify very completely this entirely original action, whose necessity has been demonstrated by the great theory of Helmholtz.

Thrown directly against each other by means of two different boxes, two equal rings slacken their speed and spread out indefinitely; and the same thing happens when they come in contact with a solid wall. But if they merely pass each other with a slight grazing of their edges (as happens in a liquid with two drops that follow one another close together on different routes), they are observed at the moment of the shock to be put out of shape without breaking and without swerving, and then to rebound immediately to their original form like an India-rubber spring. This character of resistance and of annular elasticity is certainly the most striking thing in these singular forms, these true magazines of energy wherein is accumulated, under the influence of external frictions, the entire primitive living force.

Theoretically, vortex motion, in a perfect fluid, can neither be created nor destroyed; eternal as matter itself, it has neither beginning nor end. It is inscissile, indivisible. Bring the edge of a highly-tempered blade near it as quickly as you will, says Prof. Tait, and you will succeed neither in cutting it nor even in touching it; escaping in the distance or distorting itself around the material object, it remains one and always itself. It is a true *atom* in the etymological sense of the word; and provided we consider so many remarkable properties as a whole, and provided we trace back, on an other hand, certain doctrines that are now in vogue in science—the magnetism of Ampère and the rotatory polarization of Fresnel—we shall no longer be surprised that the modern English school—Rankine and Maxwell at the head—have been able to base thereon a complete atomic theory, renewing more happily Descartes's great attempt, and embracing in one vast synthesis all branches of physics, from gravitation up to the most rebellious of all—electricity.

This is not the place for us to dwell upon the numerous practical applications connected with the theory of our "little rings in water," such as the laws of winds and tides, construction of ships, etc., and we shall therefore close by citing an almost puerile experiment, which was indicated by Helmholtz at the end of the famous memoir wherein, laying down for the first time the equations of vortex motion, he had just triumphed over a mathematical difficulty that had until then been regarded as insurmountable.

When the rounded end of a spoon or knife is placed for a moment on the surface of a liquid, there takes place all around it a vortical agitation in the form of a vertical *half* ring whose internal contours correspond with the half circular edge of the solid object, while to the right and to the left are the two portions of a same diametrical section which should exactly reproduce the schemes of our Fig. 2 (C). There is nothing neater in fact than those curlings made on the surface of black coffee by milk, and there is nothing easier than to study thus all the mutual reactions of these vortexes which are quite like those that the rower sees running at the edge of his oar and which can be reproduced on a sufficiently large scale in the bathing tub. These are experiments within the reach of everybody, and which permit every one to investigate, as a pastime, certain peculiar cases which will remain for a long time yet beyond the reach of analysis.—*Adrien Guebhard, in La Nature.*

* In the transparency of water the edges of the arches are much more marked than the rest of the tissue, which is scarcely visible.

THE INTERNATIONAL EXHIBITION OF ELECTRICITY.

THE great nave of the Palais is furnished with lamps of every kind, which are pretty equally distributed throughout its area. The twenty-nine apartments on the gallery are illuminated each by a single system. This arrangement will enable comparisons to be fairly drawn between the various systems exhibited.

In this department of the exhibition the name of Edison becomes very familiar. He has a big boiler, a big engine, and a great number of separate lamps. First, we find him using a boiler of 150-horse power; then a steam-engine of 125-horse power, of Armington's make. This transfers a speed of 360 revolutions a minute to the armature of a dynamo-electric machine. This armature weighs more than 3½ tons. It is drawn across the lines of force of a magnetic field; which magnetic field is produced by three electro-magnets, converging at their points. These electro-magnets are not in the general circuit. The duty of the armature is 120-horse power, according to the statements made; that is to say, 96 per cent. of the work done on the dynamo-electric engine appears as the energy of an effective current of electricity. This installation, the entire weight of which amounts to about 30 tons, is to keep aglow 1,000 incandescent Edison burners, 700 on the great staircase and 150 in each of the two rooms assigned to him in the gallery. But this is much cry for little wool. The lamps are unanimously said to give—we wait a day for ocular demonstration—not more than 16-candle light each, the usual run being about 10 or 12. Suppose it to be 12, 1,000 such lamps burning for an hour give 12,000-candle light. The engine has been passing, according to the statements approved of by the parties interested, 120-horse power of work into the wire, in the shape of electricity. That is to say, the effective result is 100 to 130 candles per horse power—a deplorable loss of light. A thousand rushlights would look brilliant, and no doubt the 1,000 incandescent burners will produce a fine display; but when we think of the 150-horse power boiler and the 125-horse power engine, any tendency which might be felt to rush away and invest money in Edison's incandescent burners may be modified and sobered down, if not obliterated. Compare this performance with that of a 4-horse power "Otto" gas motor setting in action a Gramme machine and a Serrin regulator, such as that used in the French lighthouses, which furnish a single arc-light of 3,000 candles, and this at the cost of about 40 cubic feet of gas, that, if burned in the usual way, would only give at most the light of 300 or 400 candles for an hour.

This is, it seems, as far as one can yet judge, the great lesson of the exhibition to gas managers. Gas is not being used at present in the most economical way, and so there is a certain tendency on the part of some gas companies, though not of others, to regard the electric light as a formidable competitor. There is no doubt that it alters the condition of the market in which the gas companies offer their goods; but it alters it for the better. Our fathers were quite contented with means of illumination varying between rushlights and wax candles, with which we should now be profoundly discontented. There is no doubt that if we were to behold their social entertainments, in which candles afforded what was for the time a relatively brilliant light, their glow would to us appear darkness. So if people go out of doors and become accustomed to the brilliant light of the voltaic arc, when they go indoors again they are not contented with a single burner, but become extravagant in their ideas and demand more light, which they naturally obtain by burning more gas. They do become more critical, however, and acquire a power of closer observation of the relative size of the blue and the yellow in the gas flame, which enables them with greater effect to grumble and express dissatisfaction if they think they have good cause. This attempt to divide the electric light at all hazards, so as to render it suitable for domestic use, is the result of a general feeling that competition is a good thing, that the light of gas is too yellow, and that it vitiates the air too much. As for the last, the people who could afford the luxury of electric fittings could

equally afford to adapt proper ventilating arrangements to their gas fittings; and as for the yellowness of gaslight, there is quite a field open for any one who will show the public the effect of using shades stained a light blue of the proper depth. The use of the electric light for domestic purposes does not seem to answer any peremptory demand. We can already obtain as much light as we wish within certain wide limits. Besides these considerations, we must also take into account the inherent inactivity of the average human being. Gas is a very convenient thing. One has only to turn it on when one wants to light it, and turn it off when one wishes to extinguish it; but the average householder troubles himself no farther. He buys burners for 1d. each, and leaves them in position till there is a crust on the top of them. He never thinks of attending to the wants of his meter. His numerous performances—thrusting knives into the burners, driving nails through the pipes, and so on are the terror and despair of the gas manager. Is such an average householder suddenly to change his nature, and to become wide awake in view of the humoring required by an insulated wire and an incandescent philosophical instrument?

At Menlo Park, it is credibly reported (contrary to the affirmations of Mr. Edison, it is fair to say) that 200 incandescent burners were set at work, and that 198 of these successively withdrew themselves from active operations in a period of two months. But it will be said that these were the paper carbon lamps; now some endogenous vegetable fiber is employed. This is not unexceptionable. The fiber is very brittle, and breaks in the lamp when it is jerked. Enough could be seen here in Room 23, three weeks ago, when all was in confusion, to enable the question to be asked: Were there exactly 1,000 Edison lamps brought over, or was an allowance made for breakage; and if so, how great? The things are too delicate to be knocked about, and even though they should come into tolerably extensive use, it can hardly be belived that, as at present constructed, they will continue to be permanently acceptable when left in unskilled hands. Mr. Edison is a wonderfully ingenious man, but it has hardly been to the advantage of his scientific reputation to have fallen into the hands of New York capitalists. He seems to be so busy striving and inventing that he has no time to read; and, like the scriptural householder, he brings forward things new and old out of his treasury. His big dynamo electric machine, for instance, is not spoken of with overwhelming respect by French scientific men, who amuse themselves by pointing out its plentiful lack of originality. His part in this exhibition is one which brings him very prominently before the public eye; but the scientific visitor, while he accords unrestrained admiration to the Edison of 1878–78, cannot but wish that the Edison of 1878–81 had lived the tranquil scientific life which is better adapted to develop his undoubted talents.

Mr. Hiram Maxim, of Bridgeport, Connecticut, already well known by his regulator—the principle of the action of which is, that when a current is not passing through the arc the carbons come rapidly toward one another, but that when the current is so passing they approach one another very gradually—illustrates his system of voltaic-arc lighting by two large burners of 40,000 candles each, which are placed in the roof of the building, and by ten smaller lamps of 2,000 candles each, which are placed on the ground floor. He also illuminates one of the halls on the gallery, Salle C, by a series of incandescent burners, 65 in the ceiling, and 16 wall lamps with 6 burners in each. Mr. Maxim's generating machine is very skillfully contrived. One difficulty in the practical construction of an electrical illuminating circuit is that, if one lamp be put out of circuit, the rest have a stronger current sent through them. This might be ruinous, say, to a few lamps lit during the early part of the evening, or to the last burners of the midnight current; but in this generator the intensity of the current produced is exactly proportional to the number of lamps in action, and thus the risk of danger is obviated. The Maxim incandescent burners resemble the Edison in having a thin fiber of carbonaceous matter, but this is made of cardboard, and stands in a rarefied atmosphere (1-103,000th) of gazoline. The United States Electric Lighting Company, who supply Maxim's instruments, have just conducted a successful negotiation with Mr. Edison for the right to use a carbon incandescent lamp.

The difficulty in making all these incandescent carbon lamps has been in the air which fills the globe. The carbon naturally burns if it be brought to a white heat in air. Hence Starr, as far back as 1845, used the Torricellian vacuum, and in this brought a carbon or platinum thread to incandescence. In 1846 Greener and Staite patented a slight improvement in it—the purification of the carbon by hydrochloric acid. There the matter lay till some Russian physicists took it up again, without, however, very much success. Then Edison reinvented the whole affair. It is curious to note that both Edison and Maxim have used platinum spirals and abandoned them. The first platinum spiral was used by Moleyns, of Cheltenham, in 1841. Edison's lamp contained a provision for allowing some of the current to run to waste when the platinum coil was getting too hot. Maxim tried from the beginning to make the current proportional only to the requirements of the case.

Mr. Swan has carried out the idea of carbon incandescence with the care which always distinguishes him. Many years ago he experimented on this subject, but not being able to produce a perfect vacuum, he found that in course of time a black deposit fouled the inside of the globe. Now he uses a Sprengel pump, and does this while the carbon is white hot, so that every trace of air is removed from the pores of the carbon. This has a great effect in improving the action of the lamp, and preventing any disintegration of the carbon. Necessarily, however, subdivision is secured at the cost of a waste of energy. The lecture hall, or hall of the Congress of Electricians, is lit by some 350 of Swan's carbon lamps, as also is the refreshment room, Salle 21, and the British office and the British Post Office exhibition. Sir W. Armstrong has set these up in his house, his motive power being a waterfall at a distance of a mile. Success under such conditions does not, however, necessarily imply success in the domestic illumination of a town.

Besides these systems of lighting by the incandescence of carbon, which is not intended to suffer any material alteration, and is, therefore, secluded from external interference, there are other systems—those of Reynier and Werdermann—which permit the incandescent carbon to burn, but replace it at the same spot as rapidly as it is consumed. In some cases the current is allowed to pass through a rod, and from it to the surface of a block of carbon. The difficulty in this case is that when the rod always rests on the same part of the carbon block, any impurities in the materials employed produce a pile of ashes at that spot, and this impedes the current. In Reynier's lamp this is obviated by making the lower block a vertical disk, on the edge of which the lower end of the rod rests. The disk is mounted on an axis, and as the upper rod wears away and descends, its descent causes the disk to rotate slightly, and thus always to present a fresh surface to the descending rod of carbon. The more recent models of Reynier's lamp do not contain this rotating disk, but simply a block of carbon. The reason of this is that carbons are now made of very excellent quality, so as to leave very little ash. Reynier's lamp, so modified, very closely resembles Werdermann's, in which, however, the block is above, and the rod ascends toward it. These lamps—Reynier's and Werdermann's—both furnish a quantity of light, varying, according to the strength of the current actuating them, from that of 40 to 400 candles. A one-horse power engine can keep in a state of incandescence three lamps of 400 candles each, or five lamps of 80 candles each. This shows how light is lost when an attempt is made to supply too many lamps from the same source of electricity. The parent of all these lamps is that of Cromwell Varley, patented in 1876, in which a descending rod of carbon impinges on the edge of a rotating wheel composed of sectors alternately conducting and insulating. As this wheel rotated the current became intermittent, and each conducting contact produced a spark; thus the end of the carbon rod was maintained in a state of ignition. The nature of the incandescence is compound—partly white hot carbon, partly flame, partly a true voltaic arc containing white hot gas and particles of carbon. These lamps are of a very convenient form for practical use. The firm of Gagneau & Co., of Paris, show a beautiful dining-room candelabrum, in which there are 24 wax candles. When these are lit they shed a very soft and agreeable light; but the pulling of a cord starts a central Werdermann light in the upper part of the candelabrum, which, under favorable conditions, would drown the 24 candles in its own 400-candle glory; and a touch of a spring lights two handsome chimney-piece lamps, also containing Werdermann burners. There is possibly something in the future of these large incandescent lamps when they are adapted to increase the brilliancy of social life; but our information as to their lasting powers is very deficient. Some have soon failed; others are said to have shone continuously, with proper renewal of the carbons, for months. Three such lamps as these would very satisfactorily light a small dining room in a mansion house; they might be kept going by a 1 or 1½ horse power engine for a Gramme machine in the basement; but this would be a luxury unattainable in ordinary cases. If, however, the use of dynamo-electric machines spread among us, and we drove our machinery by electricity which we took—like gas—by meter, an upper class household might become a customer, and occasionally illuminate its house in a splendid way at moderate expense.—*Journal of Gas Lighting.*

ELECTRICAL NIGHT-SIGNAL FOR RAILWAYS.

As well known, signals designed for preventing the collision of railroad trains consist especially of disks which are maneuvered at a distance. The maneuvering levers are located either at the station, at a bifurcation, or, in a general way, at the point to be protected, and motion is transmitted by means of an iron wire to the disk or target, located at a distance of several hundred feet. In proportion as the speed of trains has increased, the disks have had to be removed farther and farther from the station, and thus it happens frequently that they are not visible from the point from whence they are maneuvered.

It is, however, indispensable that the person charged with this maneuver shall be able to control the working of the disk and make himself certain, without leaving his post, that the signals are properly transmitted as he intended, otherwise very grave accidents may supervene.

On many railway lines this control is effected in a very simple and practical manner by means of electrical signals. A pile is located near the disk; one of its poles is put in communication with the earth, and the other is connected with the spindle of the disk, which carries a commutator that establishes or breaks communication with the fixed point

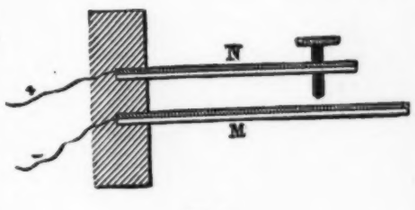
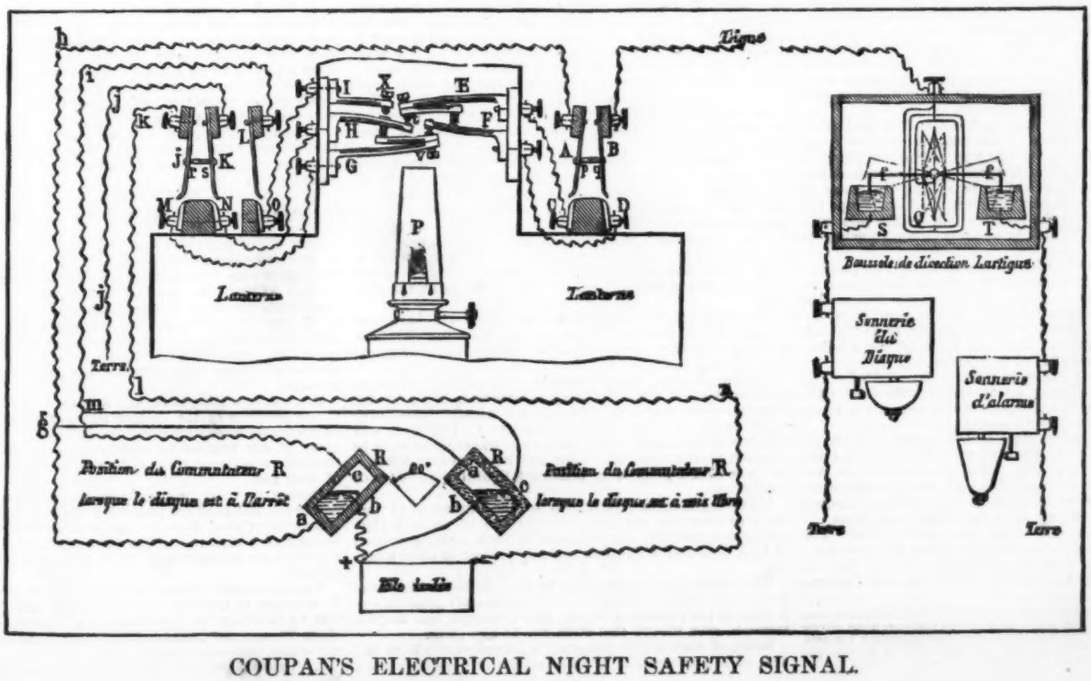


Fig. 1.

from whence the wire runs to the maneuvering station. At the extremity of this telegraphic wire there is placed an electric signal bell in connection with the earth. It is easily understood that a simple rotation of the disk, interrupting or establishing the current, will cause the bell to ring as long as the disk gives warning to stop, and will silence it when the latter is at its position, showing that the way is clear. This apparatus effectually controls the working of disks during the day-time, and gives every security to the persons charged with maneuvering them; but, at night, such is no longer the case. In fact, night signals are given by means of colored lanterns placed on the disks. As long as these are lighted, their operation being intimately connected with that of the disks, the electric bell suffices as a means of control; but they are liable to be extinguished by winds, frost, or other accidental causes, and it is, therefore, highly necessary that the persons who maneuver the disks should be notified of this at once, and that too without any trouble on their part.

To supply such a want, various apparatus, utilizing generally the expansion of metal plates, have been invented. We may cite, especially, that of Mr. Dufau, and the metallic thermoscope of Mr. Hardy, which was tried on the Western Railway in 1859 and 1860, and which, at the conclusion of the experiments, was recommended by the Minister of Public Works.

Mr. Coupan, graduate of the Ecole Centrale, and now chief of construction to the Seudre Railway, took up this study in 1869, in conjunction with Mr. Allard, and, on the same data as those of Mr. Hardy, made a series of experiments which were interrupted by the war of 1870. In 1872, after new experiments, he proposed to the railway of the North an apparatus on the subject of which Messrs.



COUPAN'S ELECTRICAL NIGHT SAFETY SIGNAL.

Tesse and Lartigue have addressed to Mr. Mathias a favorable report, pointing out, however, some imperfections.

Mr. Coupan thinks that he has completely solved the problem by means of a new arrangement. His improved apparatus, which he calls the "photo electric thermo avertisseur," is based on the curvature that metal plates composed of two unequally expansible metals undergo under the influence of heat.

Let us suppose two plates, M and N, thus arranged, fixed in an insulating post, and each communicating with one of the poles of a pile. If we submit them to a current of hot gas, each of the plates, owing to the inequality of expansion of the metals of which it is composed, will curve, and the curvature will depend upon the length of the plates and the respective quantity of the two metals of which each is formed. They are, then, true thermometers. Practically, these thermometers are constructed in such a way that one of the two is more sensitive and more impressionable than the other. Under the influence of the current of hot gas the more sensitive thermometer, M, curving rapidly, comes in contact with the screw, V, of the thermometer, N, and thus closes the electric circuit. The thermometer, N, it is true, curves in the same direction; but, its curve being less, the contact remains permanent as long as the current of hot gas remains constant. If it is suddenly suppressed, the impressionable characteristics of the thermometer, M, immediately manifest themselves, and, influenced more rapidly than the other by the change of temperature, it separates almost instantaneously from the screw, V, thus producing an interruption of the electric current. If, on the contrary, the cooling of the warm current of gas be slow and gradual, time is given for an equilibrium to be established between the temperatures of the two thermometers, and the straightening is effected without the contact ceasing until the minimum temperature for which the thermometers have been constructed is reached, and below which the electric current is interrupted.

If an apparatus of this kind be placed over the lantern of a railway disk, we have all the elements of an electrical system for making known, by means of a special alarm signal, the sudden extinction of the flame or the decrease of the light to a point where it is no longer visible. Such is the principle of Mr. Coupan's apparatus, which we shall now describe, and the general plan of which may be seen in Fig. 2. The disk to which Mr. Coupan has applied his invention is of the model used by the Railway of the North, in which the lantern is fixed to the disk, and revolves with it. The pile is placed near the disk, its positive pole connecting with a Lartigue commutator*, R, actuated by the disk itself, following its movements, and setting up a communication with other commutators, A, B, J, K, L, placed on the red face of the disk.

The negative pole communicates directly with the commutators of the face of the disk, between which are interposed the metallic thermometers, E, F, G, H, I, or, through the intermedium of these, with the earth.

During the day-time, when the lantern is absent, the operation of these different apparatus is as follows:

1.—*Disk showing the way clear; lantern absent.* Communication of the positive pole of the pile with the line wire is interrupted, and the negative pole communicates with the earth. There is, then, no current in the line wire.

2.—*Disk showing signal to stop; lantern absent.* The negative pole communicates with the earth and the positive pole with the line wire, which is thus traversed by a positive current actuating the electric signal bell. But before reaching the latter, the current traverses a Lartigue direction-compass, which, according to the direction of the current sent into the wire, establishes communication (by means of a magnetized needle, *f f*, one or the other of whose extremities dips into the mercury), either with the ordinary signal bell of the disk, or with an alarm bell having a different tone; these two bells, however, being in communication with the earth. In the second case, examined above, that is to say, that of a positive current traversing the line wire, communication is established with the ordinary signal bell.

It will be seen from what precedes that, during the day-time, when the lantern is not displayed on the disk, nothing is changed in the normal working of the apparatus; the ordinary signal bell rings when the disk is set at a warning to stop, and is silent when its position shows that the way is clear.

When night service is established, the lantern must be fixed to the disk. This lantern carries on the inside of its chimney, fixed by means of insulating mountings, five metallic thermometers, constructed on the principle already explained and designed for forming or interrupting different contacts, according as the lamp flame is at its normal brilliancy, is diminishing in intensity, or is entirely extinguished. The lantern carries, in addition, externally, three insulating prisms, C, D, M, N, O, which are provided upon their lateral faces with metallic armatures in communication with the thermometers fixed in the chimney.

By the sole fact of being mounted on the disk, and without any special manipulation of the man charged with this maneuver, the insulating prisms put themselves in contact, through their metallic armatures, with the commutators on the red face of the disk, and in separating the plates of which the said commutators are composed, interrupt the direct communication of the positive pole of the pile with the line wire, when the disk is at its position signaling to stop.

When the lantern is in place on the disk, the two poles of the pile are in communication through the Lartigue commutator, the commutators of the red face of the disk and the prisms, with the five metallic thermometers; and then, according as the lamp flame acts well or poorly, or as the disk signals to "stop," or that "the way is clear," there follow results which it remains for us to examine.

3.—*Disk showing the way clear; the lantern lighted.* The negative pole of the pile communicates with the earth; the communication of the positive pole of the line wire is interrupted; and the alarm does not sound.

4.—*Disk showing signal to stop; lantern lighted.* The negative pole of the pile communicates with the earth and the positive pole with the line wire. The direction of the current traversing this wire is positive, and the Lartigue compass sets up a communication with the ordinary electric bell, which operates exactly as under normal conditions.

5.—*Disk showing the way clear; lamp extinguished.* The negative pole of the pile communicates with the line wire, and the positive pole with the earth. The line is then, in this case, traversed by a negative current, and the Lartigue compass sends the current into the alarm bell, which then begins to ring.

6.—*Disk showing signal to stop; lantern extinguished.* Just as in the preceding case, the negative pole of the pile communicates with the line wire and the positive pole with the earth, and the line is traversed by a negative current which sounds the alarm.

It will be seen from what precedes, that the addition of Mr. Coupan's apparatus to the disks has no influence on their working during the day-time, and that the ordinary electrical bell continues to ring while the disk signals to stop, and is silent when the way is clear. It is the same at night, as long as the light of the lantern is at its normal brilliancy; but, if this brilliancy decreases sensibly, or the flame is extinguished suddenly, the alarm bell begins to ring and continues to do so until the lamp is relighted, no matter what be the position of the disk.

As a result of numerous trials made by Mr. Coupan, it is found that notification of the extinction, or even of a considerable lowering of the light, is given within eight or ten seconds.

It may be said, then, that by the aid of this apparatus, warning of the poor working of the lantern is given instantaneously, thus permitting those in charge to take precautions to signal by means of torpedoes or otherwise, when the disk does not operate in a normal manner.

This is a very important result, and one which seems to us to promise a great future for Mr. Coupan's "photo-avertisseur." It should be remarked, in addition, that this apparatus operates by the aid of an ordinary pile and an ordinary line wire, thus materially reducing the cost of establishing it and keeping it in operation.—*Le Génie Civil.*

* The Lartigue commutator consists of an ebonite box containing mercury, its sides being traversed at certain points by platinum wires serving as contacts. By inclining the box, the mercury touches certain contacts, uncovers others, and, consequently, can send the current in one direction or the other.

ACTION OF LIGHTNING UPON TELEPHONE APPARATUS.

In these days of popular science, every one knows that lightning is the discharge of atmospheric electricity, and that it seeks under all circumstances the easiest and shortest road to the earth. The wide range of usefulness which the telephone has taken upon itself brings the subject of the present article home to every telephone manager and even to every telephone user. It cannot be denied that the majority of the latter class have a vivid impression that wires of any kind on a house make that house very liable to a lightning stroke, and that telegraph or telephone wires are especially subject to such a drawback.

Many people who would otherwise rent and use a telephone are, by this apprehension, debarred from that privilege, or, if they have one, they live in a state of chronic disquietude arising from the thought that they are harboring a destroying angel, as it were, who at any time may turn and rend them.

This apprehension is well known by practical electricians to be to a great extent without legitimate foundation, but, nevertheless, it prevails and cannot be overlooked. Only those miserable and unfortunate persons whose terrible doom it has been to solicit roof permits from householders can appreciate the sentiment in all its glaring force. The proposal to establish a fixture upon the roof belonging to a free-born American citizen usually calls forth very severe objurgations upon the bloated corporations in the person of their unoffending agent then present. The assertion uniformly made by the agent, that the wires running over a house are absolutely a protection, instead of dangerous, is treated by the American citizen with undisguised scorn, as advanced by an interested party.

The American citizen cannot be so easily imposed upon. He has never seen any one killed by electricity, but he has heard that such things are possible; therefore he has no desire to have wires worked by electricity placed on the top of his house. He has been told that a wire leading from the top of a house attracts lightning. What can be more logical than that a wire running *over* your roof will also attract lightning, and, of course, after having attracted the lightning to the house, the death-dealing and treacherous wire has done its work, because, as the wire does not run down the wall into the ground, the lightning must necessarily go through the house in its endeavor to reach the earth.

Such are the arguments of the free-born citizen when he condescends to argue at all.

The wires must, however, be stretched, and in fact always are stretched.

It is a fact also, that, where there are a sufficient number of wires crossing any roof, they form practically a much more reliable safeguard against destruction from lightning discharges than do fifty per cent. of the lightning rods, since they must, in order to perform their legitimate functions satisfactorily, form a good connection with the ground in at least one of their terminals. Even when but a few wires cross a roof they protect that roof to a considerable extent. That property is protected by the wires passing over it needs no other proof than the fact that the lower part of New York, which is literally covered by a network of wires, has for many years possessed almost perfect immunity from lightning casualties.

This immunity to the property under and surrounding the wires is, unfortunately, in a great measure at the expense of the wires themselves, or of the fixtures, poles, or electrical apparatus, as has been frequently proven by disastrous experience. During the present summer the fatality has been unusually great among the coils of magneto bells, telephones, and Blake transmitters. A certain amount of such trouble and annoyance must always be expected and counted upon as one of the inherent features of the business.

To enable amateur telephonists and others who have been brought by the force of circumstances into the telephone business to reduce this loss and annoyance to a minimum, this article is written.

Telephone lines, when properly constructed, are not so liable to damage from lightning as telegraph lines, for the common-sense reason that they do not usually extend over anything like so large a section of territory. Lightning will take the shortest path to the earth even though that path be of much greater resistance than the longer route; hence it has been found possible to construct lightning arresters or protectors.

Lightning is neither restricted to the properties of machine or frictional electricity nor to those of galvanic electricity, but partakes of the nature of both, being possessed of high potential in addition to being present in large quantity.

This latter is, of course, due to the electromotive force with which it is propelled, being so enormously great in proportion to the resistance which the discharge has to pass through, even though that discharge be also great.

Being of such a high potential or having such a high tension, as is demonstrated by its capability of passing through such wonderful distances of air as it does, it follows that we can construct a protector based upon the principle previously enunciated, that lightning will take a short route through the imperfect conductor in preference to a longer one through a good conductor.

Telephone managers, then, who have erected upon their lines the so called induction appliances, consisting of ground wires extending down the poles and branch wires along the cross arms, can console their wounded pocketbooks with the reflection that, even should these appliances prove ineffectual for the purpose for which they were erected, with a slight alteration, namely, continuing the connection of the cross-arm wire up to a point outside though not touching the insulator and facing the wire, and extending the upright pole wire a little distance above the top of the pole, a reliable lightning conductor is established and the poles and wire protected.

Even in their present condition they do efficient service. Each magnet bell is or should be furnished with a lightning arrester of some kind, usually a plate connected with each entering wire placed close on either side of a plate with saw-like teeth which is connected to the ground.

Any one wishing additional security may add to this different forms of protector. For instance, it may be of use to place near the point where the wires enter the office a cylindrical piece of brass connected to the ground, and insert in the line circuit on both entering wires a piece of fine silk-covered wire. The lightning in this case, instead of passing through the magnet or transmitter coils, will go to earth at the metallic cylinder. There is, however, a serious objection to all protectors of this class, especially when at a distance from the central office, for the reason that when a discharge takes place through them they are more than likely to be ruined. On this account we give some precautions which every telephone constructor can employ with great advantage and at little or no additional cost.

First, owing to the second attribute of electricity (its considerable quantity), it will heat, sometimes to the melting point, and destroy the wire unless its conducting path be large enough and the ground wire be both low in resistance and of considerable size; and it will also, in its attempt to choose another route to the earth, be likely to destroy a good deal of the apparatus, burning and melting the metal parts, and breaking to pieces all the non-conducting portions.

It is the part of wisdom, then, with all those who deplore such wholesale destruction of property to see that they have a ground wire of large substance and also surface, and that such a ground wire makes a perfect connection with the ground. In a former article we gave our views on ground wires, and will not repeat them here. It is not, however, as well understood as it should be that a lightning arrester ground, whether at a central office or at a subscriber's office, in order to be of any practical utility, must be of large size, and, moreover, its connections must be of large surface and thoroughly attached. For size we would say not less than five-sixteenths of an inch, iron or copper wire. The connection may properly be made on a water or gas pipe as usual; but if a gas pipe is used and the connection made on the house side of the meter, the meter should invariably be bridged with a stout piece of copper wire, to improve the conductivity and also to prevent the meter from receiving damage.

The older magneto bells had but one binding screw for their local battery connection, and it was customary for the individual connecting them to connect the other battery wire into one of the main line connection screws. This, of course, left one end of the primary coil of the transmitter always in connection with the line, and in the event of the line receiving a lightning discharge, a portion of it would frequently seek earth through the primary coil and across to the secondary, burning both out in transit. Therefore, if you have to connect a bell with but one local battery screw, don't connect the other battery wire in the line post, but in the upper telephone connecting screw on the right-hand side of the bell. Bells are now made with binding screws for all the necessary wires.

Some exchanges have been fitted with protective appliances to be attached to their line wires on the approach of a lightning storm.

The contrivances are especially applicable to small exchanges where all the wires can be easily controlled by one person, but they are readily modified so that they can be applied to exchanges of any size.

The contrivance consists generally in so arranging the apparatus that, on the approach of a thunderstorm, all the lines are put directly to earth. A brass plate is arranged behind the switch board, crossing all the wires; this plate is fixed upon pivots, and is in permanent connection with a very large ground wire. On the approach of a storm a lever attached to the plate is depressed, bringing the plate into good contact with all the line wires or with a series of small plates connected to them at a point before the line wires reach the annunciators.

This, of course, puts them all to ground, and it is found that wherever this arrangement is used the destruction of bells and transmitter coils is materially lessened.—*The Operator.*

SIEMENS' REGENERATIVE GAS-BURNERS.

The use of powerful luminous foci, with the exception of those employed in lighthouses and in a very few industrial operations, does not date back farther than two or three years. At that time the Jablochkoff candles were making their first appearance in our streets and other public places. At the very first the light of these appeared dazzling and even fatiguing on account of its unsteadiness and its changes of color; but it was not long before people got so familiar with the use of intense lights that the latter ceased to attract any attention.

Gas was unwilling to occupy a back seat in the presence of the progress of the electric light, and while electricians on their side were attempting the division of light, the engineers of gas companies were, on the contrary, applying themselves to the problem of increasing the luminous power of their foci.

During the past two or three years a large number of new types, designed for producing foci varying between five and twenty Carcel burners, has been invented; but it must be confessed that researches have not always been happy, and that the progress made up to the present time has been dubious.

The regenerative intensifying gas-burners invented by Mr. F. Siemens, of Dresden, have singularly modified this situation by proving the possibility of obtaining with gas foci of 50, 75, and 100 Carcel burners under conditions of economy which are comparable with those of the electric light.

As well known, the illuminating power of flames pro-

duced by the combustion of gas is due to the presence of particles of carbon passing to a state of ignition and afterwards of combustion; and there is no white light produced unless there is a preliminary decomposition of the carbureted gases. This decomposition is facilitated, and the brilliancy of the light produced by the ignition of the particles of carbon is developed by increasing the temperature of the flame. To effect the latter it suffices to supply the combustion with hot air; and air may for this purpose be heated by the aid of the very products of combustion. It is on this principle that Mr. Siemens' intensifying burner is based.

The apparatus consists of three principal parts: The *burner*, properly so called; the *regenerator*, in which the air necessary for combustion is first heated in contact with the sides of the central cylinder in which circulates a portion of the products of combustion; and the *draught chimney*, which serves for carrying off these products.

The burner consists of an annular fascicle of small copper tubes, *m*, one-fifth of an inch in diameter, the number varying from fifteen to thirty-two according to the power of the apparatus.

The gas, when introduced into the space, A, traverses these tubes and becomes considerably heated, without, however, acquiring a temperature sufficient to decompose it and thus to give rise to deposits of soot.

The relatively large diameter of the orifices which admit the gas has the double advantage of preventing the orifices from fouling through accidental deposits of soot and of diminishing the velocity of the flow of gas.

The air enters the apparatus through the annular orifice below the apparatus, and rises through the natural draught due to its being heated, into the annular space, C, between the external copper cylinder and the internal copper chimney, B.

In this ascensional movement the air becomes heated in contact with the sides of the chimney, B, and, on approaching the level of the upper orifice of the small tubes which conduct the gas, meets a flat ring, *a*, having a series of teeth cut in its interior margin, which divides it into a series of thin plates. The gas itself is also divided at a point above this by a similar ring whose teeth are external, instead of internal. By this means an intimate mixture of the two gases, combustible and combustive, is assured. Combustion is then effected, and the flame produced has the aspect of a beautiful luminous sheet as it rises around the hollow cylinder, C, of refractory material which surmounts and terminates the central chimney, B.

At the upper edge of the cylinder, *c*, the luminous flame is inverted and carried inwardly as a consequence of the draught set up by the bent side chimney, G, which connects the central chimney, B, with the upper chimney, E.

The flame on descending into the central chimney raises the sides of the latter to a temperature of about 600°. It is by contact with this heated chimney that the air necessary for the combustion acquires its temperature of nearly 500°.

The products of combustion thus partially cooled escape through the bent chimney, G, into the upper one, E, which carries them out of the apartment that is being lighted.

Thus the circulation of the gas, air, and products of combustion, between which the exchange of heat must be made, is effected in a methodical and rational manner, the gas and air rising as fast as they become cool.

Fig. 1 represents in section a closed burner, that is, one surrounded by a globe, D; but the apparatus, with a few modifications, is capable of operating in the open air and even without a lateral chimney, as shown in Fig. 2.

The draught of the products of combustion is effected by means of a central tube, H, which descends into the interior of the refractory cylinder, *c*, and of the space, B. The direction of the arrows indicates the course taken by the different gases.

The prime advantage of the Siemens burner is evidently the increase of illuminating power resulting from the use of heated air in the regenerator. The photometric measurements made with the different Siemens burners give the result tabulated below:

Number of Burner Tubes.	Consumption per hour.	Light produced in Carcels.	Gas burned per hour and per unit of light.
10	150	2 to 3	1·75 to 2·6 c. ft.
15	250 to 300	6 to 7 Carcels	1·4 to 2 "
18	650	15	
24	800	20 to 21	1·3 to 1·4 "
32	1,605	46 to 48	1·2 to 1·25 "
48	2,200	72	1 "

It may be said, then, that the illuminating power of a same volume of gas is tripled. It results from this that the same quantity of light can be obtained with these burners by consuming three times less gas than would be used in ordinary apparatus, and which amounts to the same as if gas were supplied at one-third the price that it now costs.

The coal usually employed for manufacturing gas produces a product whose type varies from 3·68 to 3·85 cubic feet. Poor gases are enriched by cannel coal, which, distilled alone, gives a gas whose illuminating power is 2·1 cubic feet; and, finally, by the distillation of boghead, a rich gas is obtained whose illuminating power is 1·25 cubic feet. The Siemens burner, then, gives the same light as if it were supplied with gas from boghead coal, and by boghead coal gas costing the same price per cubic foot as gas from ordinary coal; and it therefore solves the problem so often attempted in the use of carbureters—the enrichment of the gas, and that too without expense.

These apparatus permit of an almost indefinite increase of the power of luminous foci, for there is nothing to prevent the construction of burners to consume 70 to 100 cubic feet or more, that is to say, giving a light equal to 60 to 100 Carcels and beyond. Besides, the smallest sized burner, consuming 5·25 cubic feet only, more than realizes the utilization of gas that had heretofore been effected only by means of intensifying burners of large consumption.

Finally, the Siemens burners have another advantage, and that is of allowing the products of combustion to be expelled. In living rooms and in public halls, it is well known that the deleterious effects of the presence in the air of nitrogen, carbonic acid, and sulphureted hydrogen, arising from the combustion of gas, are to be dreaded. It will be very easy, however, with these new apparatus, to lead the products of combustion out of doors, by directing the draught chimneys into special flues in the walls or ceiling. There is nothing, then, to prevent the extension of gas lighting into theaters and other places of public assemblage.

At the last meeting held by the Société de l'Industrie Technique du Gaz, held at Nantes, during the very interesting lecture of Mr. Marché on the Siemens apparatus, three of the latter—one of 90 c. f., and the other two of 28 c. f.—were exhibited in operation and drew forth numerous compliments from the engineers assembled.

Fig. 1.

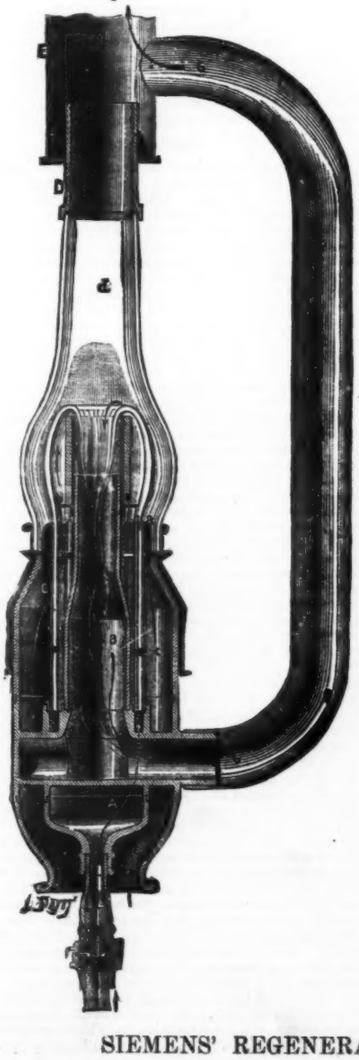
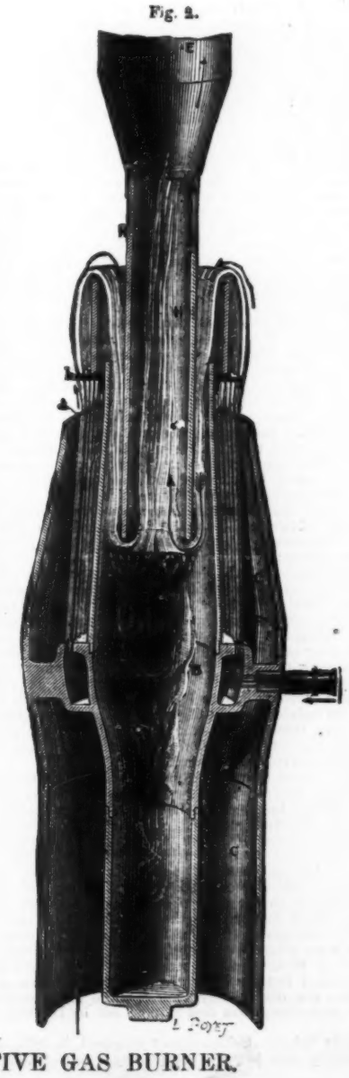


Fig. 2.



SIEMENS' REGENERATIVE GAS BURNER.

BRITISH ASSOCIATION.—PRESIDENT'S ADDRESS.

AT the fifty-first meeting of the British Association for the Advancement of Science, commenced at York on August 31, Sir John Lubbock, F.R.S., Pres. Linn. Soc., the president, delivered an address as follows:

After a few words referring to York as the cradle of the association, the first meeting having been held there in 1831, the president went on to say: Certainly this is an opportunity on which it may be well for us to consider what have been the principal scientific results of the last half-century, dwelling especially on those with which the association is more directly concerned, either as being the work of our own members, or as having been made known at our meetings. It is, of course, impossible within the limits of a single address to do more than allude to a few of these, and that very briefly. In dealing with so large a subject I first hoped that I might take our annual volumes as a text book. This, however, I at once found to be quite impossible. For instance, the first volume commences with a report on astronomy, by Sir G. Airy: I may be pardoned, I trust, for expressing my pleasure at finding that the second was one by my father, on the tides, prepared, like the preceding, at the request of the council; then comes one on meteorology by Forbes, radiant heat by Baden Powell, optics by Brewster, mineralogy by Whewell, and so on. My best course will, therefore, be to take our different sections one by one, and endeavor to bring before you a few of the principal results which have been obtained in each department. The biological section is that with which I have been most intimately associated, and with which it is, perhaps, natural that I should begin.

THE PROGRESS OF BIOLOGY.

Fifty years ago it was the general opinion that animals and plants came into existence just as we now see them. We took pleasure in their beauty; their adaptation to their habits and mode of life in many cases could not be overlooked or misunderstood. Nevertheless, the book of nature was like some richly illumined missal, written in an unknown tongue; the graceful forms of the letters, the beauty of the coloring, excited our wonder and admiration; but of the true meaning little was known to us—indeed we scarcely realized that there was any meaning to decipher. Now glimpses of the truth are gradually revealing themselves; we perceive that there is a reason—and in many cases we know what that reason is—for every difference in form, in size, and in color; for every bone and every feather, almost for every hair. Moreover, each problem which is solved opens out vistas, as it were, of others perhaps even more interesting. With this great change the name of our illustrious countryman, Darwin, is intimately associated, and the year 1859 will always be memorable in science as having produced his great work on "The Origin of Species." In the previous year, he and Wallace had published short papers in which they clearly state the theory of natural selection at which they had simultaneously and independently arrived. We cannot wonder that Darwin's views should have at first excited great opposition. Nevertheless from the first they met with powerful support, especially, in this country, from Hooker, Huxley, and Herbert Spencer. The theory is based on four axioms: "1. That no two animals or plants in nature are identical in all respects. 2. That the offspring tend to inherit the peculiarities of their parents. 3. That of those which come into existence, only a small number reach maturity. 4. That those which are, on the whole, best adapted to the circumstances in which they are placed are most likely to leave descendants."

Darwin commenced his work by discussing the causes and extent of variability in animals, and the origin of domestic varieties; he showed the impossibility of distinguishing between varieties and species, and pointed out the wide differences which man has produced in some cases—as, for instance, in our domestic pigeons, all unquestionably descended from a common stock. He dwelt on the struggle for existence (which has since become a household word), and which, inevitably resulting in the survival of the fittest, tends gradually to adapt any race of animals to the conditions in which it occurs. While thus, however, showing the great importance of natural selection, he attributed to it no exclusive influence, but fully admitted that other causes—the use and disuse of organs, sexual selection, etc.—had to be taken into consideration. Passing on to the difficulties of his theory he accounted for the absence of intermediate varieties between species, to a great extent, by the imperfection of the geological record. But if the geological record be imperfect it is still very instructive. The further paleontology has progressed, the more it has tended to fill up the gaps between existing groups and species, while the careful study of living forms has brought into prominence the variations dependent on food, climate, habitat, and other conditions, and shown that many species long supposed to be absolutely distinct are so closely linked together by intermediate forms that it is difficult to draw a satisfactory line between them. The principles of classification point also in the same direction, and are based more and more on the theory of descent. Biologists endeavor to arrange animals on what is called the "natural system." No one now places whales among fish, bats among birds, or shrews with mice, notwithstanding their external similarity; and Darwin maintained that "community of descent was the hidden bond which naturalists had been unconsciously seeking." How else, indeed, can we explain the fact that the framework of bones is so similar in the arm of a man, the wing of a bat, the fore-leg of a horse, and the fin of a porpoise—that the neck of a giraffe and that of an elephant contain the same number of vertebræ? Strong evidence is, moreover, afforded by embryology; by the presence of rudimentary organs and transient characters, as, for instance,

the existence in the calf of certain teeth which never cut the gums, the shriveled and useless wings of some beetles, the presence of a series of arteries in the embryos of the higher Vertebrata exactly similar to those which supply the gills in fishes, even the spots on the young blackbird, the stripes on the lion's cub; these, and innumerable other facts of the same character, appear to be incompatible with the idea that each species was specially and independently created; and to prove, on the contrary, that the embryonic stages of species show us more or less clearly the structure of their ancestors.

Darwin's views, however, are still much misunderstood. I believe there are thousands who consider that according to his theory a sheep might turn into a cow, or a zebra into a horse. No one would more confidently withstand any such hypothesis, his view being, of course, not that the one could be changed into the other, but that both are descended from a common ancestor.

No one, at any rate, will question the immense impulse which Darwin has given to the study of natural history, the number of new views he has opened up, and the additional interest which he has aroused in and contributed to biology. When we were young we knew that the leopard had spots, the tiger was striped, and the lion tawny; but why this was so it did not occur to us to ask; and if we had asked no one would have answered. Now we see at a glance that the stripes of the tiger have reference to its life among jungle grasses; the lion is sandy, like the desert; while the marking of the leopard resembles spots of sunshine glancing through the leaves.

THE SCIENCE OF EMBRYOLOGY

may almost be said to have been created in the last half-century. Fifty years ago it was a very general opinion that animals which are unlike when mature, were dissimilar from the beginning. It is to Von Baer, the discoverer of the mammalian ovum, that we owe the great generalization that the development of the egg is in the main a progress from the general to the special, in fact that embryology is the key to the laws of animal development. Thus the young of existing species resemble in many cases the mature forms which flourished in ancient times. Huxley has traced up the genealogy of the horse to the Miocene Anchitherium. In the same way Gaudry has called attention to the fact that just as the individual stag gradually acquires more and more complex antlers, having at first only a single prong, in the next year two points in the following three, and so on; so the genus, as a whole, in Middle Miocene times, had two pronged horns; in the Upper Miocene, three; and that it is not till the Upper Pliocene that we find any species with the magnificent antlers of our modern deer. It seems to be now generally admitted that birds have come down to us through the Dinosaurians, and, as Huxley has shown, the profound break once supposed to exist between birds and reptiles has been bridged over by the discovery of reptilian birds and bird-like reptiles; so that, in fact, birds are modified reptiles. Again, the remarkable genus Peripatus, so well studied by Moseley, tends to connect the annulose and articulate types. Again the structural resemblances between Amphioxus and the Ascidians had been pointed out by Goodsir; and Kowalevsky in 1866 showed that these were not mere analogies, but indicated a real affinity. These observations, in the words of Allen Thomson, "have produced a change little short of revolutionary in embryological and zoological views, leading, as they do, to the support of the hypothesis that the Ascidian is an earlier stage in the phylogenetic history of the mammal and other vertebrates. The larval forms which occur in so many groups, and of which the insects afford us the most familiar examples, are, in the words of Quatrefages, embryos, which lead an independent life. In such cases as these external conditions act upon the larvæ as they do upon the mature form; hence we have two classes of changes, adaptational or adaptive, and developmental. These and many other facts must be taken into consideration; nevertheless, naturalists are now generally agreed that embryological characters are of high value as guides in classification, and it may, I think, be regarded as well established that, just as the contents and sequence of rocks teach us the past history of the earth, so is the gradual development of the species indicated by the structure of the embryo and its developmental changes. When the supporters of Darwin are told that his theory is incredible, they may fairly ask why it is impossible that a species in the course of hundreds of thousands of years should have passed through changes which occupy only a few days or weeks in the life-history of each individual?

The phenomena of yelk segmentation, first observed by Prevost and Dumas, are now known to be in some form or other invariably the precursors of embryonic development; while they reproduce, as the first stages in the formation of the higher animals, the main and essential features in the life-history of the lowest forms. The "blastoderm," as it is called, or first germ of the embryo in the egg, divides into two layers, corresponding, as Huxley has shown, to the two layers into which the body of the Cœlenterata may be divided. Not only so, but most embryos at an early stage of development have the form of a cup, the walls of which are formed by the two layers of the blastoderm. Kowalevsky was the first to show the prevalence of this embryonic form, and subsequently Lankester and Haeckel put forward the hypothesis that it was the embryonic repetition of an ancestral type, from which all the higher forms are descended. The cavity of the cup is supposed to be the stomach of this simple organism, and the opening of the cup the mouth. The inner layer of the wall of the cup constitutes the digestive membrane, and the outer the skin. To this form Haeckel gave the name Gastræa. It is, perhaps, doubtful whether the theory of Lankester and Haeckel can be accepted in precisely the form they propounded it; but it has had an important influence on the progress of embryology. I cannot quit the science of embryology without alluding to the very admirable work on "Comparative Embryology" by our new general secretary, Mr. Balfour, and also the "Elements of Embryology," which he had previously published in conjunction with Dr. M. Foster.

In 1842, Steenstrup published his celebrated work on the "Alternation of Generations," in which he showed that many species are represented by two perfectly distinct types or broods, differing in form, structure, and habits; that in one of them males are entirely wanting, and that the reproduction is effected by fission, or by buds, which, however, are in some cases structurally indistinguishable from eggs. Steenstrup's illustrations were mainly taken from marine or parasitic species, of very great interest, but not generally familiar, excepting to naturalists. It has since been shown that the common Cynips or Gallfly is also a case in point. It had long been known that in some genera belonging to this group, males are entirely wanting, and it has now been shown by Bassett, and more thoroughly by Adler, that some of these species are double-brooded; the two broods having been considered as distinct genera.

Thus an insect known as *Neuroterus lenticularis*, of which females only occur, produces the familiar oak spangles so common on the undersides of oak leaves, from which emerge, not *Neuroterus lenticularis*, but an insect hitherto considered as a distinct species, belonging even to a different genus, *Spathegaster baccarum*. In Spathegaster both sexes occur; they produce the currant-like galls found on oaks, and from these galls Neuroterus is again developed. So also the King Charles oak apples produce a species known as *Teras terminalis*, which descends to the ground, and makes small galls on the roots of the oak. From these emerge an insect known as *Biorhiza aptera*, which again gives rise to the common oak apple. It might seem that such inquiries as these could hardly have any practical bearing. Yet it is not improbable that they may lead to very important results. For instance, it would appear that the fluke which produces the rot in sheep passes one phase of its existence in the black slug, and we are not without hopes that the researches, in which our lamented friend, Prof. Rolleston, was engaged at the time of his death, which we all so much deplore, will lead, if not to the extirpation, at any rate to the diminution of a pest from which our farmers have so grievously suffered.

It was in the year 1839 that Swann and Schleiden demonstrated the intimate relation in which animals and plants stand to each other, by showing the identity of the laws of development of the elementary parts in the two kingdoms of organic nature.

As regards descriptive biology, by far the greater number of species now recorded have been named and described within the last half century. Dr. Günther has been good enough to make a calculation for me. The numbers, of course, are only approximate, but it appears that while the total number of animals described up to 1831 was not more than 70,000, the number now is at least 320,000. Lastly, to show how large a field still remains for exploration, I may add that Mr. Waterhouse estimates that the British Museum alone contains not fewer that 12,000 species of insects which have not yet been described, while our collections do not probably contain anything like one-half of those actually in existence. Further than this, the anatomy and habits even of those which have been described offer an inexhaustible field for research, and it is not going too far to say that there is not a single species which would not amply repay the devotion of a lifetime.

One remarkable feature in the modern progress of biological science has been the application of improved methods of observation and experiment; and the employment in physiological research of the exact measurements employed by the experimental physicist. Our microscopes have been greatly improved. The use of chemical reagents in microscopical investigations has proved most instructive, and another very important method of investigation has been the power of obtaining very thin slices by embedding the object to be examined in paraffin or some other soft substance. In this manner we can now obtain, say, fifty separate sections of the egg of a beetle, or the brain of a bee.

VEGETABLE PHYSIOLOGY.

At the close of the last century Sprengel published a most suggestive work on flowers, in which he pointed out the curious relation existing between these and insects, and showed that the latter carried the pollen from flower to flower. His observations, however, attracted little notice until Darwin called attention to the subject in 1862. It had long been known that the cowslip and primrose exist under two forms, about equally numerous, and differing from one another in the arrangements of their stamens and pistils; the one form having the stamens on the summit of the flower and the stigma half way down; while in the other the relative positions are reversed, the stigma being at the summit of the tube and the stamens half way down. This difference had, however, been regarded as a case of mere variability; but Darwin showed it to be a beautiful provision, the result of which is that insects fertilize each flower with pollen brought from a different plant; and he proved that flowers fertilized with pollen from the other form yield more seed than if fertilized with pollen of the same form, even if taken from a different plant.

Attention having been thus directed to the question, an astonishing variety of the most beautiful contrivances have been observed and described by many botanists, especially Hooker, Axel, Delpino, Hildebrand, Bennett, Fritz. Müller, and above all Hermann Müller and Darwin himself. The general result is that to insects, and especially to bees, we owe the beauty of our gardens, the sweetness of our fields. To their beneficent, though unconscious action, flowers owe their scent and color, their honey—nay, in many cases, even their form. Their present shape and varied arrangements, their brilliant colors, their honey, and their sweet scent are all due to the selection exercised by insects.

In these cases the relation between plants and insects is one of mutual advantage. In many species, however, plants present us with complex arrangements adapted to protect them from insects; such, for instance, are in many cases the resinous glands which render leaves unpalatable; the thickets of hairs and other precautions which prevent flowers from being robbed of the honey by ants. Again, more than a century ago, our countryman, Ellis, described an American plant, Dionæa, in which the leaves are somewhat concave, with long lateral spines and a joint in the middle, which close up with a jerk, like a rat trap, the moment any unwary insect alights on them. The plant, in fact, actually captures and devours insects. This observation also remained as an isolated fact until within the last few years, when Darwin, Hooker, and others have shown that many other species have curious and very varied contrivances for supplying themselves with animal food.

Some of the most fascinating branches of botany, morphology, histology, and physiology, scarcely existed before 1830. In the two former branches the discoveries of Von Mohl are pre-eminent. He first observed cell division in 1835, and detected the presence of starch in chlorophyl corpuscles in 1837, while he first described protoplasm, now so familiar to us, at least by name, in 1846. In the same year Amici discovered the existence of the embryonic vesicle in the embryo sac, which develops into the embryo when fertilized by the entrance of the pollen-tube into the micropyle. The existence of sexual reproduction in the lower plants was doubtful, or at least doubted by some eminent authorities, as recently as 1853, when the actual process of fertilization in the common bladderwrack of our shores was observed by Thuret, while the reproduction of the larger fungi was first worked out by De Bary in 1863.

As regards lichens, Schwendener proposed, in 1869, the startling theory, now however accepted by some of the highest authorities, that lichens are not autonomous organisms, but commensal associations of a fungus parasitic on an alga. With reference to the higher Cryptogams, it is hardly too much to say that the whole of our exact knowledge of their life history has been obtained during the last half century. Thus, in the case of ferns the male organs, or antheridia, were first discovered by Nägeli in 1844, and the archegonia, or female organs, by Suminski in 1848. The early stages in the development of mosses were worked out by Valentine in 1833. Lastly, the principle of alternation of generations in plants was discovered by Hofmeister. This eminent naturalist also, in 1851–54, pointed out the homologies of the reproductive processes in mosses, vascular cryptogams, gymnosperms, and angiosperms.

Nothing could have appeared less likely than that researches into the theory of spontaneous generation should have led to practical improvements in medical science. Yet such has been the case. Only a few years ago bacteria seemed mere scientific curiosities. It has long been known that an infusion—say, of hay—would, if exposed to the atmosphere, be found after a certain time to teem with living forms. Even those few who still believe that life would be spontaneously generated in such an infusion, will admit that these minute organisms are, if not entirely, yet mainly, derived from germs floating in our atmosphere; and if precautions are taken to exclude such germs, as in the careful experiments especially of Pasteur, Tyndall, and Roberts, every one will grant that in ninety-nine cases out of a hundred no such development of life will take place. These facts have led to most important results in surgery. One reason why compound fractures are so dangerous is because, the skin being broken, the air obtains access to the wound, bringing with it innumerable germs, which too often set up putrefying action. Lister made a practical application of these observations. He set himself to find some substance capable of killing the germs without being itself too potent a caustic, and he found that dilute carbolic acid fulfilled these conditions. This discovery has enabled many operations to be performed which would previously have been almost hopeless. The same idea seems destined to prove as useful in medicine as in surgery. There is great reason to suppose that many diseases, especially those of a zymotic character, have their origin in the germs of special organisms. We know that fevers run a certain definite course. The parasitic organisms are at first few, but gradually multiply at the expense of the patient, and then die out again. Indeed, it seems to be thoroughly established that many diseases are due to the excessive multiplication of microscopic organisms, and we are not without hope that means will be discovered, by which, without injury to the patient, these terrible, though minute, enemies may be destroyed, and the disease thus stayed. The interesting researches of Burden-Sanderson, Greenfield, Koch, Pasteur, Toussaint, and others, seem to justify the hope that we may be able to modify these and other germs, and then by appropriate inoculation to protect ourselves against fever and other acute diseases. The history of anæsthetics is a most remarkable illustration of how long we may be on the very verge of a most important discovery. Ether, which, as we all know, produces perfect insensibility to pain, was discovered as long ago as 1540. The anæsthetic property of nitrous oxide, now so extensively used, was observed in 1800 by Sir H. Davy, who actually experimented on himself, and had one of his teeth painlessly extracted when under its influence. He even suggests that "as a nitrous oxide gas seems capable of destroying pain, it could probably be used with advantage in surgical operations." Nay, this property of nitrous oxide was habitually explained and illustrated in the chemical lectures given in hospitals, and yet for fifty years the gas was never used in actual operations.

ANTHROPOLOGY.

Few branches of science have made more rapid progress in the last half century than that which deals with the ancient condition of man. When our association was founded it was generally considered that the human race suddenly appeared on the scene, about 6,000 years ago, after the disappearance of the extinct mammalia, and when Europe, both as regards physical conditions and the other animals by which it was inhabited, was pretty much in the same condition as in the period covered by Greek and Roman history. Since then the persevering researches of Layard, Rawlinson, Botta, and others have made known to us, not only the statues and palaces of the ancient Assyrian monarchs, but even their libraries; the cuneiform characters have been deciphered, and we can not only see, but read, in the British Museum, the actual contemporary records, on burnt-clay cylinders, of the events recorded in the historical books of the Old Testament and in the pages of Herodotus. The researches in Egypt also seem to have satisfactorily established the fact that the pyramids themselves are at least 6,000 years old, while it is obvious that the Assyrian and Egyptian monarchies cannot suddenly have attained to the wealth and power, the state of social organization and progress in the arts, of which we have before us preserved by the sand of the desert from the ravages of man, such wonderful proofs.

In Europe the writings of the earliest historians and poets indicated that, before iron came into general use, there was a time when bronze was the ordinary material of weapons, axes, and other cutting implements, and though it seemed *a priori* improbable that a compound of copper and tin should have preceded the simple metal iron, nevertheless the researches of archæologists have shown that there really was in Europe a "Bronze Age," which at the dawn of history was just giving way to that of "Iron." The contents of ancient graves, buried in many cases so that their owner might carry some at least of his wealth with him to the world of spirits, left no room for doubt as to the existence of a Bronze Age; but we get a completer idea of the condition of man at this period from the Swiss lake-villages, first made known to us by Keller. Along the shallow edges of the Swiss lakes there flourished, once upon a time, many populous villages or towns, built on platforms supported by piles, exactly as many Malayan villages are now. Under these circumstances innumerable objects were one by one dropped into the water; sometimes whole villages were burnt and their contents submerged; and thus we have been able to recover from the waters of oblivion, in which they had rested for more than 2,000 years, not only the arms and tools of this ancient people, the bones of their animals, their pottery and ornaments, but the stuffs they wore, the grain they had stored up for future use, even fruits and cakes of bread. But this bronze-using people were not the earliest occupants of Europe. The contents of ancient tombs give evidence of a time when metal was unknown. This was also confirmed by the evidence then unexpectedly received from the Swiss lakes. By the side of the bronze-age villages were others, not less extensive, in which, while implements of stone and bone were discovered literally by thousands,

not a trace of metal was met with. The shell-mounds or refuse-heaps accumulated by the ancient fishermen along the shores of Denmark confirmed the existence of a "Stone Age."

No bones of the reindeer, no fragment of any of the extinct mammalia, have been found in any of the Swiss lake-villages or in any of the thousands of tumuli which have been opened in our own country or in Central and Southern Europe. Yet the contents of caves and of river-gravels afford abundant evidence that there was a time when the mammoth and rhinoceros, the musk-ox and reindeer, the cave lion and hyena, the great bear and the gigantic Irish elk, wandered in our woods and valleys, and the hippopotamus floated in our rivers; when England and France were united and the Thames and the Rhine had a common estuary. This was long supposed to be before the advent of man. At length, however, the discoveries of Boucher de Perthes in the valley of the Somme, supported as they are by the researches of many Continental naturalists, and in our own country of MacEnery and Godwin-Austen, Prestwich and Lyell, Vivian and Pengelly, Christy, Evans, and many more, have proved that man formed a humble part of this strange assembly. Nay, even at this early period there were at least two distinct races of men in Europe; one of them—as Boyd Dawkins has pointed out—closely resembling the modern Esquimau in form, in his weapons and implements, probably in his clothing, as well as in so many of the animals with which he was associated. At this stage man appears to have been ignorant of pottery, to have had no knowledge of agriculture, no domestic animals, except perhaps the dog. His weapons were the ax, the spear, and the javelin. I do not believe he knew the use of the bow, though he was probably acquainted with the lance. He was, of course, ignorant of metal, and his stone implements, though skilfully formed, were of quite different shapes from those of the Second Stone Age, and were never ground. This earlier Stone period, when man co-existed with these extinct mammalia, is known as the Palæolithic or Early Stone Age, in opposition to the Neolithic or Newer Stone Age. The remains of the mammalia which coexisted with man in prehistoric times have been most carefully studied by Owen, Lartet, Rütimeyer, Falconer, Busk, Boyd-Dawkins, and others. The presence of the mammoth, the reindeer, and especially of the musk ox, indicates a severe, not to say an arctic, climate, the existence of which, moreover, was proved by other considerations; while, on the contrary, the hippopotamus requires considerable warmth. How then is this association to be explained?

While the climate of the globe is, no doubt, much affected by geographical conditions, the cold of the glacial period was, I believe, mainly due to the eccentricity of the earth's orbit combined with the obliquity of the ecliptic. The result of the latter condition is a period of 21,000 years during which one half of the northern hemisphere is warmer than the southern, while during the other 10,500 years the reverse is the case. At present we are in the former phase, and there is, we know, a vast accumulation of ice at the south pole. But when the earth's orbit is nearly circular, as it is at present, the difference between the two hemispheres is not very great; on the contrary, as the eccentricity of the orbit increases the contrast between them increases also. This eccentricity is continually oscillating within certain limits, which Croll and subsequently Stone, have calculated out for the last million years. At present the eccentricity is 0·016, and the mean temperature of the coldest month in London is about 40°. Such has been the state of things for nearly 100,000 years; but before that there was a period, 300,000 years ago, when the eccentricity of the orbit varied from 0·26 to 0·57. The result of this would be greatly to increase the effect due to the obliquity of the orbit; at certain periods the climate would be much warmer than at present, while at others the number of days in winter would be twenty more, and of summer twenty less than now, while the mean temperature of the lowest month would be lowered 20°. We thus get something like a date for the last glacial epoch, and we see that it was not simply a period of cold, but rather one of extremes, each beat of the pendulum of temperature lasting for no less than 21,000 years. This explains the fact that, as Morlot showed in 1854, the glacial deposits of Switzerland, and, as we now know, those of Scotland, are not a single uniform layer, but a succession of strata indicating very different conditions. I agree also with Croll and Geikie in thinking that these considerations explain the apparent anomaly of the coexistence in the same gravels of arctic and tropical animals; the former having lived in the cold, while the latter flourished in the hot, periods. It is I think, now well established that man inhabited Europe during the milder periods of the glacial epoch. Some high authorities, indeed, consider that we have evidence of his presence in preglacial and even in Miocene times, but I confess that I am not satisfied on this point. Even the more recent period carries back the record of man's existence to a distance so great as altogether to change our views of ancient history. Nor is it only as regards the antiquity and material condition of man in prehistoric times that great progress has been made. If time permitted I should have been glad to have dwelt on the origin and development of language, of custom, and of law. On all of these the comparison of the various lower races still inhabiting so large a portion of the earth's surface has thrown much light; while even in the most cultivated nations we find survivals, curious fancies, and lingering ideas—the fossil remains, as it were, of former customs and religions embedded in our modern civilization, like the relics of extinct animals in the crust of the earth.

GEOLOGY AND PALEONTOLOGY.

In geology the formation of our Association coincided with the appearance of Lyell's "Principles of Geology," the first volume of which was published in 1830 and the second in 1832. At that time the received opinion was that the phenomena of geology could only be explained by violent periodical convulsions, and a high intensity of terrestrial energy culminating in repeated catastrophes. Hutton and Playfair had indeed maintained that such causes as those now in operation would, if only time enough were allowed, account for the geological structure of the earth; nevertheless the opposite view generally prevailed, until Lyell, with rare sagacity and great eloquence, with a wealth of illustration and most powerful reasoning, convinced geologists that the forces now in action are powerful enough, if only time be given, to produce results quite as stupendous as those which science records.

As regards stratigraphical geology, at the time of the first meeting of the British Association at York, the strata between the carboniferous limestone and the chalk had been mainly reduced to order and classified, chiefly through the labors of William Smith. But the classification of all the strata lying above the chalk and below the carboniferous limestone respectively, remained in a state of the greatest confusion. The year 1831 marks the period of the commencement of the joint labors of Sedgwick and Murchison, which resulted in the establishment of the Cambrian, Silurian, and Devonian systems. Our pre-Cambrian strata have recently been divided by Hicks into four great groups of immense thickness, and implying, therefore, a great lapse of time; but no fossils have yet been discovered in them. Lyell's classification of the Tertiary deposits, the result of the studies which he carried on with the assistance of Deshayes and others, was published in the third volume of the "Principles of Geology" in 1833. The establishment of Lyell's divisions of Eocene, Miocene, and Pliocene, was the starting point of a most important series of investigations by Prestwich and others of these younger deposits, as well as of the post-tertiary, quaternary, or drift beds, which are of special interest from the light they have thrown on the early history of man.

As regards the physical character of the earth, two theories have been held: one, that of a fluid interior covered by a thin crust; the other, of a practically solid sphere. The former is now very generally admitted, both by astronomers and geologists, to be untenable. The prevailing feeling of geologists on this subject has been well expressed by Professor Le Conte, who says: "The whole theory of igneous agencies—which is little less than the whole foundation of theoretic geology—must be reconstructed on the basis of a solid earth." In 1837 Agassiz startled the scientific world by his "Discours sur l'ancienne extension des Glaciers," in which, developing the observation already made by Charpentier and Venetz, that bowlders had been transported to great distances, and that rocks far away from, or high above, existing glaciers, are polished and scratched by the action of ice, he boldly asserted the existence of a "glacial period," during which Switzerland and the North of Europe were subjected to great cold and buried under a vast sheet of ice. The ancient poets described certain gifted mortals as privileged to descend into the interior of the earth, and have exercised their imagination in recounting the wonders there revealed. As in other cases, however, the realities of science have proved more varied and surprising than the dreams of fiction. Of the gigantic and extraordinary animals thus revealed to us, by far the greatest number have been described during the period now under review. For instance, the gigantic Cetiosaurus was described by Owen in 1838, the Dinornis of New Zealand by the same distinguished naturalist in 1839, the Mylodon in the same year, and the Archæopteryx in 1862. In America a large number of remarkable forms have been described, mainly by Marsh, Leidy, and Cope. Marsh has made known to us the Titanosaurus of the American (Colorado) Jurassic beds, which is, perhaps, the largest land animal yet known, being 100 feet in length, and at least 30 feet in height, though it seems possible that even these vast dimensions were exceeded by those of the Atlantosaurus. Nor must I omit the Hesperornis, described by Marsh in 1872, as a carnivorous, swimming ostrich, provided with teeth, which be regards as a character inherited from reptilian ancestors; the Ichthyornis, stranger still, with biconcave vertebræ, like those of fishes, and teeth set in sockets.

As giving, in a few words, an idea of the rapid progress in this department, I may mention that Morris' "Catalogue of British Fossils," published in 1843, contained 5,300 species; while that now in preparation by Mr. Etheridge enumerates 15,000. But if these figures show how rapid our recent progress has been, they also very forcibly illustrate the imperfection of the geological record, and give us, I will not say a measure, but an idea of the imperfection of the geological record. The number of all the described recent species is over 300,000, but certainly not half are yet on our list, and we may safely take the total number of recent species as being not less than 700,000. But in former times there have been at the very least twelve periods, in each of which by far the greater number of species were distinct. True, the number of species was probably not so large in the earlier periods as at present; but if we make a liberal allowance for this, we shall have a total of more than 2,000,000 species, of which about 25,000 only are as yet upon record; and many of these are only represented by a few, some only by a single specimen, or even only by a fragment. The progress of paleontology may also be marked by the extent to which the existence of groups has been, if I may so say, carried back in time. Thus I believe that in 1830 the earliest known quadrupeds were small marsupials belonging to the Stonesfield slates; the most ancient mammal now known is *Microlestes antiquus* from the Keuper of Würtemberg; the oldest bird known in 1881 belonged to the period of the London clay, the oldest now known is the Archæopteryx of the Solenhofen slates, though it is probable that some at any rate of the footsteps on the Triassic rocks are those of birds. So again the amphibia have been carried back from the Trias to the Coal-measures; fish from the Old Red Sandstone to the Upper Silurian; reptiles to the Trias; insects from the Cretaceous to the Devonian; mollusca and crustacea from the Silurian to the Lower Cambrian. The rocks below the Cambrian, though of immense thickness, have afforded no relics of animal life, if we except the problematical Eozoon Canadense, so ably studied by Dawson and Carpenter. But if paleontology as yet throws no light on the original forms of life, we must remember that the simplest and the lowest organisms are so soft and perishable that they would leave "not a wreck behind."

GEOGRAPHICAL DISCOVERY.

Passing to the science of geography, Mr. Clements Markham has recently published an excellent summary of what has been accomplished during the half-century. The progress in our knowledge of geography is and has been by no means confined to the improvement of our maps or to the discovery and description of new regions of the earth, but has extended to the causes which have led to the present configuration of the surface. To a great extent, indeed, this part of the subject falls rather within the scope of geology, but I may here refer, in illustration, to the distribution of lakes, the phenomena of glaciers, the formation of volcanic mountains and the structure and distribution of coral islands. The origin and distribution of lakes is one of the most interesting problems in physical geography. That they are not scattered at random, a glance at the map is sufficient to show. They abound in mountain districts, are comparatively rare in equatorial regions, increasing in number as we go north, so that in Scotland and the northern parts of America they are sown broadcast.

Perhaps *a priori* the first explanation of the origin of lakes which would suggest itself would be that they were formed in hollows resulting from a disturbance of the strata, which had thrown them into a basin-shaped form. Lake-basins, however, of this character are, as a matter of fact, very rare; as a general rule lakes have not the form of basin-shaped synclinal hollows, but, on the contrary, the strike of the strata often runs right across them. My eminent predecessor, Professor Ramsay, divides lakes into three classes: (1) Those which are due to irregular accumulations of drift, and which are generally quite shallow. (2) Those which are formed by moraines, and (3) those which occupy true basins scooped by glacier ice out of the solid rock. To the latter class belong most of the great Swiss and Italian lakes. Professor Ramsay attributes their excavation to glaciers, because it is of course obvious that rivers cannot make basin-shaped hollows surrounded by rock on all sides. Now the Lake of Geneva, 1,230 feet above the sea, is 984 feet deep; the Lake of Brienz is 1,850 feet above the sea and 2,000 feet deep, so that its bottom is really below the sea level. The Italian lakes are even more remarkable. The Lake of Como, 700 feet above the sea, is 1,929 feet deep. Lago Maggiore, 685 feet above the sea, is no less than 2,635 feet deep. It will be observed that these lakes, like many others in mountain regions, those of Scandinavia, for instance, lie in the direct channels of the great old glaciers. If the mind is at first staggered by the magnitude of the scale, we must remember that the ice which scooped the valley in which the Lake of Geneva now reposes was once at least 2,700 feet thick, while the moraines were also of gigantic magnitude, that of Ivrea, for instance, being no less than 1,500 feet in height. Professor Ramsay's theory seems, therefore, to account beautifully for a large number of interesting facts.

VOLCANOES, GLACIERS, AND CORAL ISLANDS.

Passing from lakes to mountains, two rival theories with reference to the structure and origin of volcanoes long struggled for supremacy. The more general view was that the sheets of lava and scoriæ which form volcanic cones—such, for instance, as Ætna or Vesuvius—were originally nearly horizontal, and that subsequently a force operating from below, and exerting a pressure both upward and outward from a central axis toward all points of the compass, uplifted the whole stratified mass and made it assume a conical form, giving rise at the same time, in many cases, to a wide and deep circular opening at the top of the cone, called by the advocates of this hypothesis a "crater of elevation." This theory, though, as it seems to us now, it had already received its death-blow from the admirable memoirs of Scrope, was yet that most generally adopted fifty years ago, because it was considered that compact and crystalline lavas could not have consolidated on a slope exceeding 1° or 2°. In 1858, however, Sir C. Lyell conclusively showed that in fact such lavas could consolidate at a considerable angle, even in some cases at more than 30°, and it is now generally admitted that though the beds of lava, etc., may have sustained a slight angular elevation since their deposition, still in the main volcanic cones have acquired their form by the accumulation of lava and ashes ejected from one or more craters.

The problems presented by glaciers are of very great interest. In 1843 Agassiz and Forbes proved that the center of a glacier, like that of a river, moves more rapidly than its sides. But how and why do glaciers move at all? Rendu, afterwards Bishop of Annecy, in 1841 endeavored to explain the facts by supposing that glacier ice enjoys a kind of ductility. The "viscous" theory of glaciers was also adopted, and most ably advocated by Forbes, who compared the condition of a glacier to that of the contents of a tar barrel poured into a sloping channel. We have all, however, seen long, narrow fissures, a mere fraction of an inch in width stretching far across glaciers—a condition incompatible with the ordinary idea of viscosity. The phenomenon of regelation was afterward applied to the explanation of glacier-motion. An observation of Faraday's supplied the clew. He noticed in 1850 that when two pieces of thawing ice are placed together they unite by freezing at the place of contact. Following up this suggestion, Tyndall found that if he compressed a block of ice in a mould it could be made to assume any shape he pleased. A straight prism, for instance, placed in a groove and submitted to hydraulic pressure, was bent into a transparent semicircle of ice. These experiments seem to have proved that a glacial valley is a mould through which the ice is forced, and to which it will accommodate itself, while, as Tyndall and Huxley also pointed out, the "veined structure of ice" is produced by pressure, in the same manner as the cleavage of slate rocks.

It was in the year 1842 that Darwin published his great work on "Coral Islands." The fringing reefs of coral presented no special difficulty. They could be obviously accounted for by an elevation of the land, so that the coral which had originally grown under water had been raised above the sea level. The circular or oval shape of so many of the reefs, however, each having a lagoon in the center, closely surrounded by a deep ocean, and rising but a few feet above the sea-level, had long been a puzzle to the physical geographer. The favorite theory was that these were the summits of sub-marine volcanoes on which the coral had grown. But as the reef making coral does not live at greater depths than about twenty-five fathoms, the immense number of these reefs formed an almost insuperable objection to this theory. The Laccadives and Maldives, for instance—meaning literally the "lac of islands" and the "thousand islands" are a series of such atolls, and it was impossible to imagine so great a number of craters, all so nearly of the same altitude. Darwin showed, moreover, that so far from the ring of corals resting upon a corresponding ridge of rock, the lagoons, on the contrary, now occupy the place which was once the highest land. He pointed out that some lagoons, as, for instance, that of Vanikoro, contain an island in the middle, while other islands, such as Tahiti, are surrounded by a margin of smooth water, separated from the ocean by a coral reef. Now, if we suppose that Tahiti were to sink slowly, it would gradually approximate to the condition of Vanikoro; and if Vanikoro gradually sank, the central island would disappear, while, on the contrary, the growth of the coral might neutralize the subsidence of the reef, so that we should have simply an atoll, with its lagoon. The same considerations explain the origin of the "barrier-reefs," such as that which runs, for nearly one thousand miles, along the northeast coast of Australia. Thus Darwin's theory explained the form and the approximate identity of altitude of these coral islands. But it did more than this, because it showed us that there were great areas in process of subsidence, which, though slow, was of great importance in physical geography. I ought to mention that Darwin's views have recently been questioned by Semper and Murray.

Much information has also been acquired with reference to the abysses of the ocean, especially from the voyages of the Porcupine and the Challenger. The greatest depth yet recorded is near the Ladrone Islands, where a sounding of 4,575 fathoms was obtained. Ehrenberg long ago pointed out the similarity of the calcareous mud now accumulating in our recent seas to the chalk, and showed that the green-

sands of the geologist are largely made up of casts of foraminifera. Clay, however, has been looked on, until the recent expeditions, as essentially a product of the disintegration of older rocks. Not only, however, are a large proportion of silicious and calcareous rocks either directly or indirectly derived from material which has once formed a portion of living organisms, but Sir Wyville Thomson maintains that this is the case with some clays also. In that, the striking remark of Linnæus, that "fossils are not the children but the parents of rocks," will have received remarkable confirmation. I should have thought it, I confess, probable that these clays are, to a considerable extent, composed of volcanic dust.

It would appear that calcareous deposits resembling our chalk do not occur at a greater depth than 3,000 fathoms; they have not been met with in the abysses of the ocean. Here the bottom consists of exceedingly fine clay, sometimes colored red by oxide of iron, sometimes chocolate by manganese oxide, and containing with Foraminifera occasionally large numbers of silicious Radiolaria. These strata seem to accumulate with extreme slowness; this is inferred from the comparative abundance of whales' bones and fishes' teeth, and from the presence of minute spherical particles supposed by Mr. Murray to be of cosmic origin—in fact to be the dust of meteorites which in the course of ages have fallen on the ocean. Such particles no doubt occur over the whole surface of the earth; but on land they soon oxidize, and in shallow water they are covered up by other deposits. Another interesting result of recent deep sea explorations has been to show that the depths of the ocean are no mere barren solitudes, as was until recent years confidently believed, but, on the contrary, present us many remarkable forms of life. We have, however, as yet but thrown here and there a ray of light down into the ocean abysses:

> "Nor can so short a time sufficient be
> To fathom the vast depths of Nature's sea."

PROGRESS IN ASTRONOMY AND SPECTRUM ANALYSIS.

In astronomy, the discovery in 1845 of the planet Neptune, made independently and almost simultaneously by Adams and by Le Verrier, was certainly one of the very greatest triumphs of mathematical genius. Of the minor planets four only were known in 1831, while the number now on the roll amounts to 220. Many astronomers believe in the existence of an intra-mercurial planet or planets, but this is still an open question. The solar system has also been enriched by the discovery of an inner ring to Saturn, of satellites to Mars, and of additional satellites to Saturn, Uranus, and Neptune. The most unexpected progress, however, in our astronomical knowledge during the past half century has been due to spectrum analysis. The dark lines in the spectrum were first seen by Wollaston, who noticed a few of them; but they were independently discovered by Fraunhofer, after whom they are justly named, and who, in 1814, mapped no fewer than 576. The first steps in "spectrum analysis," properly so called, were made by Sir J. Herschel, Fox Talbot, and by Wheatstone, in a paper read before this association in 1835. The latter showed that the spectrum emitted by the incandescent vapor of metals was formed of bright lines, and that these lines, while, as he then supposed, constant for each metal, differed for different metals. "We have here," he said, "a mode of discriminating metallic bodies more readily than that of chemical examination, and which may hereafter be employed for useful purposes." Nay, not only can bodies thus be more readily discriminated, but, as we now know, the presence of extremely minute portions can be detected, the one five-millonth of a grain being in some cases easily perceptible. It is also easy to see that the presence of any new simple substance might be detected, and in this manner already several new elements have been discovered, as I shall mention when we come to chemistry. But spectrum analysis has led to even grander and more unexpected triumphs. Fraunhofer himself noticed the coincidence between the double dark line D of the solar spectrum and a double line which he observed in the spectra of ordinary flames, while Stokes pointed out to Sir W. Thomson, who taught it in his lectures, that in both cases these lines were due to the presence of sodium. To Kirchhoff and Bunsen, however, is due the independent conception and the credit of having first systematically investigated the relation which exists between Fraunhofer's lines and the bright lines in the spectra of incandescent metals. In order to get some fixed measure by which they might determine and record the lines characterizing any given substance, it occurred to them that they might use for comparison the spectrum of the sun. They accordingly arranged their spectroscopes so that one-half of the slit was lighted by the sun, and the other by the luminous gases they proposed to examine. It immediately struck them that the bright lines in the one corresponded with the dark lines in the other—the bright line of sodium, for instance, with the line or rather lines D in the sun's spectrum. The conclusion was obvious. There was sodium in the sun! It must, indeed, have been a glorious moment when that thought flashed across them, and even by itself well worth all their labor. Kirchhoff and Bunsen thus proved the existence in the sun of hydrogen, sodium, magnesium, calcium, iron, nickel, chromium, manganese, titanium, and cobalt; since which Angstrom, Thalen, and Lockyer, have considerably increased the list.

But it is not merely the chemistry of the heavenly bodies on which light is thrown by the spectroscope; their physical structure and evolutional history are also illuminated by this wonderful instrument of research. It used to be supposed that the sun was a dark body enveloped in a luminous atmosphere. The reverse now appears to be the truth. The body of the sun, or photosphere, is intensely brilliant; round it lies the solar atmosphere of comparatively cool gases, which cause the dark lines in the spectrum; thirdly, a chromosphere—a sphere principally of hydrogen, jets of which are said sometimes to reach to a height of 100,000 miles or more, into the outer coating or corona, the nature of which is still very doubtful. Formerly the red flames which represented the higher regions of the chromosphere could be seen only on the rare occasions of a total solar eclipse. Janssen and Lockyer, by the application of the spectroscope, have enabled us to study this region of the sun at all times. It is, moreover, obvious that the powerful engine of investigation afforded us by the spectroscope is by no means confined to the substances which form part of our system. The incandescent body can thus be examined, no matter how great its distance, so long only as the light is strong enough. That this method was theoretically applicable to the light of the stars was indeed obvious, but the practical difficulties were very great. Sirius, the brightest of all, is, in round numbers, a hundred millions of millions of miles from us; and, though as big as sixty of our suns, his light when it reaches us, after a journey of sixteen years, is, at most, one two-thousand millionth part as bright. Nevertheless, as long ago as 1815, Fraunhofer recognized the fixed lines in the light of four of the stars, and in 1863 Miller and Huggins, in our own country, and Rutherfurd, in America, succeeded in determining the dark lines in the spectrum of some of the brighter stars, thus showing that these beautiful and mysterious lights contain many of the material substances with which we are familiar. In Aldebaran, for instance, we may infer the presence of hydrogen, sodium, magnesium, iron, calcium, tellurium, antimony, bismuth, and mercury; some of which are not yet known to occur in the sun. As might have been expected, the composition of the stars is not uniform, and it would appear that they may be arranged in a few well-marked classes, indicating differences of temperature, or, in other words, of age. Some recent photographic spectra of stars, obtained by Huggins, go very far to justify this view. Thus we can make the stars teach us their own composition with light which started from its source before we were born—light older than our association itself.

But spectrum analysis has even more than this to tell us. The old methods of observation could determine the movements of the stars so far only as they were transverse to us; they afforded no means of measuring motion either directly toward or away from us. Now Döppler suggested in 1841, that the colors of the stars would assist us in this respect, because they would be affected by their motion to and from the earth, just as a steam whistle is raised or lowered as it approaches or recedes from us. Every one has observed that if a train whistles as it passes us, the sound appears to alter at the moment the engine goes by. This arises, of course, not from any change in the whistle itself, but because the number of vibrations which reach the ear in a given time are increased by the speed of the train as it approaches, and diminished as it recedes. So, like the sound, the color would be affected by such a movement; but Döppler's method was practically inapplicable, because the amount of effect on the color would be utterly insensible; and, even if it were otherwise, the method could not be applied, because, as we did not know the true color of the stars, we have no datum line by which to measure.

A change of refrangibility of light, however, does occur in consequence of relative motion, and Huggins successfully applied the spectroscope to solve the problem. He took, in the first place, the spectrum of Sirius, and chose a line known as F, which is due to hydrogen. Now, if Sirius was motionless, or rather if it retained a constant distance from the earth, the line F would occupy exactly the same position in the spectrum of Sirius as in that of the sun. On the contrary, if Sirius were approaching or receding from us, this line would be slightly shifted either toward the blue or red end of the spectrum. He found that the line had moved very slightly toward the red, indicating that the distance between us and Sirius is increasing at the rate of about twenty miles a second. So also Betelgeux, Rigel, Castor, and Regulus are increasing their distance; while, on the contrary, that of others, as, for instance, of Vega, Arcturus, and Pollux, is diminishing. The results obtained by Huggins on about twenty stars have since been confirmed and extended by Mr. Christie, now Astronomer Royal, in succession to Sir G. Airy, who has long occupied the post with so much honor to himself and advantage to science. To examine the spectrum of a shooting star would seem even more difficult; yet Alexander Herschel has succeeded in doing so, and finds that their nuclei are incandescent solid bodies; he has recognized the lines of potassium, sodium, lithium, and other substances, and considers that the shooting stars are bodies similar in character and composition to the stony masses which sometimes reach the earth as aerolites.

No element has yet been found in any meteorite which was not previously known as existing in the earth, but the phenomena which they exhibit indicate that they must have been formed under conditions very different from those which prevail on the earth's surface. I may mention, for instance, the peculiar form of crystallized silica, called by Maskelyne asmanite; and the whole class of meteorites, consisting of iron generally alloyed with nickel, which Daubrée terms Holosiderites. The interesting discovery, however, by Nordenskjöld, in 1870, at Ovifak, of a number of blocks of iron alloyed with nickel and cobalt, in connection with basalts containing disseminated iron, has, in the words of Judd, "afforded a very important link, placing the terrestrial and extra-terrestrial rocks in closer relations with one another." We have as yet no sufficient evidence to justify a conclusion as to whether any substances exist in the heavenly bodies which do not occur in our earth, though there are many lines which cannot yet be satisfactorily referred to any terrestrial element. On the other hand, some substances which occur on our earth have not yet been detected in the sun's atmosphere. Such discoveries as these seemed, not long ago, entirely beyond our hopes. M. Comte, indeed, in his "Cours de Philosophie Positive," as recently as 1842, laid it down as an axiom regarding the heavenly bodies, that "Nous concevons la possibilité de déterminer leurs formes, leurs distances, leurs grandeurs et leurs mouvements, tandis que nous ne saurions jamais étudier par aucun moyen leur composition chimique ou leur structure minéralogique." Yet within a few years this supposed impossibility has been actually accomplished, showing how unsafe it is to limit the possibilities of science.

It is hardly necessary to point out that, while the spectrum has taught us so much, we have still even more to learn. Why should some substances give few, and others many lines? Why should the same substance give different lines at different temperatures? What are the relations between the lines and the physical or chemical properties. We may certainly look for much new knowledge of the hidden actions of atoms and molecules from future researches with the spectroscope. It may even, perhaps, teach us to modify our views of the so-called simple substances. Prout, long ago, struck by the remarkable fact that nearly all atomic weights are simply multiples of the atomic weight of hydrogen, suggested that hydrogen must be the primordial substance. Brodie's researches also naturally fell in with the supposition that the so-called simple substances are in reality complex, and that their constituents occur separately in the hottest regions of the solar atmosphere. Lockyer considers that his researches lend great probability to this view. The whole subject is one of intense interest, and we may rejoice that it is occupying the attention, not only of such men as Abney, Dewar, Hartley, Liveing, Roscoe, and Schuster in our own country, but also of many foreign observers. When geology so greatly extended our ideas of past time, the continued heat of the sun became a question of greater interest than ever. Helmholtz has shown that, while adopting the nebular hypothesis, we need not assume that the nebulous matter was originally incandescent; but that its present high temperature may be, and probably is, mainly due to gravitation between its parts. It follows that the potential energy of the sun is far from exhausted, and that with continued shrinking it will continue to give out light and heat, with little, if any, diminution for several millions of years.

Like the sand of the sea, the stars of heaven have ever been used as effective symbols of number, and the improvements in our methods of observation have added fresh forces to our original impressions. We now know that our earth is but a fraction of one out of at least 75,000,000 worlds. But this is not all. In addition to the luminous heavenly bodies, we cannot doubt that there are countless others, invisible to us from their greater distance, smaller size, or feebler light; indeed, we know that there are many dark bodies which now emit no light or comparatively little. Thus in the case of Procyon, the existence of an invisible body is proved by the movement of the visible star. Again I may refer to the curious phenomena presented by Algol, a bright star in the head of Medusa. This star shines without change for two days and thirteen hours; then, in three hours and a half dwindles from a star of the second to one of the fourth magnitude; and then, in another three and a half hours, reassumes its original brilliancy. These changes seem certainly to indicate the presence of an opaque body, which intercepts at regular intervals a part of the light emitted by Algol.

Thus the floor of heaven is not only "thick inlaid with patines of bright gold," but studded also with extinct stars—once probably as brilliant as our own sun, but now dead and cold, as Helmholtz tells us that our sun itself will be, some seventeen millions of years hence. The general result of astronomical researches has been thus eloquently summed up by Proctor: "The sidereal system is altogether more complicated and more varied in structure than has hitherto been supposed; in the same regions of the stellar depths coexist stars of many orders of real magnitude; all orders of nebulæ, gaseous or stellar planetary, ring-formed, elliptical, and spiral, exist within the limits of the Galaxy; and lastly, the whole system is alive with movements, the laws of which may one day be recognized, though at present they appear too complex to be understood."

LIGHT AND COLOR.

We can, I think, scarcely claim the establishment of the undulatory theory of light as falling within the last fifty years; for though Brewster, in his "Report on Optics," published in our first volume treats the question as open, and expresses himself still unconvinced, he was, I believe, almost alone in his preference for the emission theory. The phenomena of interference, in fact, left hardly any—if any—room for doubt, and the subject was finally set at rest by Foucault's celebrated experiments in 1850. According to the undulatory theory the velocity of light ought to be greater in the air than in water, while if the emission theory were correct the reverse would be the case. The velocity of light—186,000 miles in a second—is, however, so great that, to determine its rate in air, as compared with that in water, might seem almost hopeless. The velocity in the air was, nevertheless, determined by Fizeau, in 1849, by means of a rapidly revolving wheel. In the following year, Foucault, by means of a revolving mirror, demonstrated that the velocity of light is greater in air than in water—thus completing the evidence in favor of the undulatory theory of light.

The idea is now gaining ground that, as maintained by Clerk-Maxwell, light itself is an electro-magnetic disturbance, the luminiferous ether being the vehicle of both light and electricity. Wünsch, as long ago as 1792, had clearly shown that the three primary colors were red, green and violet; but his results attracted little notice, and the general view used to be that there were seven principal colors—red, orange, yellow, green, blue, indigo, and violet; four of which—namely, orange, green, indigo, and violet—were considered to arise from mixtures of the other three. Red, yellow, and blue were, therefore, called the primary colors, and it was supposed that, in order to produce white light, these three colors must always be present. Helmholtz, however, again showed, in 1852, that a color to our unaided eyes identical with white, was produced by combining yellow with indigo. At that time yellow was considered to be a simple color, and this, therefore, was regarded as an exception to the general rule, that a combination of three simple colors is required to produce white. Again, it was, and, indeed, still is, the general impression that a combination of blue and yellow makes green. This, however, is entirely a mistake. Of course we all know that yellow paint and blue paint make green paint; but this results from absorption of light by the semi-transparent solid particles of the pigments, and is not a mere mixture of the colors proceeding unaltered from the yellow and the blue particles; moreover, as can easily be shown by two sheets of colored paper and a piece of window glass, blue and yellow light, when combined, do not give a trace of green, but if pure, would produce the effect of white. Green, therefore, is, after all, not produced by a mixture of blue and yellow. On the other hand, Clerk-Maxwell proved in 1860 that yellow could be produced by a mixture of red and green, which put an end to the pretension of yellow to be considered a primary element of color. From these and other considerations it would seem, therefore, that the three primary colors—if such an expression be retained—are red, green, and violet.

The existence of rays beyond the violet, though almost invisible to our eyes, had long been demonstrated by their chemical action. Stokes, however, showed in 1852 that their existence might be proved in another manner, for that there are certain substances which, when excited by them, emit light visible to our eyes. To this phenomenon he gave the name of fluorescence. At the other end of the spectrum Abney has recently succeeded in photographing a large number of lines in the infra-red portion, the existence of which was first proved by Sir William Herschel. From the rarity, and in many cases the entire absence of reference to blue, in ancient literature, Geiger—adopting and extending a suggestion first thrown out by Mr. Gladstone—has maintained that, even as recently as the time of Homer, our ancestors were blue-blind. Though for my part I am unable to adopt this view, it is certainly very remarkable that neither the Rigveda, which consists almost entirely of hymns to heaven, nor the Zendavesta, the Bible of the Parsees or fire-worshipers, nor the Old Testament, nor the Homeric poems, ever allude to the sky as blue. On the other hand, from the dawn of poetry, the splendors of the morning and evening skies have excited the admiration of mankind. As Ruskin says, in language almost as brilliant as the sky itself, the whole heaven, "from the zenith to the horizon, becomes one molten, mantling sea of color and fire; every black bar turns into massy gold, every ripple and wave into unsullied shadowless crimson, and purple, and scarlet, and colors for which there are no words in language, and no ideas in the mind—things which

can only be conceived while they are visible; the intense hollow blue of the upper sky melting through it all, showing here deep, and pure, and lightness; there, modulated by the filmy, formless body of the transparent vapor, till it is lost imperceptibly in its crimson and gold.' But what is the explanation of these gorgeous colors? Why is the sky blue? And why are the sunrise and sunset crimson and gold? It may be said that the air is blue; but if so, how can the clouds assume their varied tints? Brücke showed that very minute particles suspended in water are blue by reflected light. Tyndall has taught us that the blue of the sky is due to the reflection of the blue rays by the minute particles floating in the atmosphere. Now if from the white light of the sun the blue rays are thus selected, those which are transmitted will be yellow, orange, and red. Where the distance is short the transmitted light will appear yellowish. But as the sun sinks toward the horizon the atmospheric distance increases, and consequently the number of the scattering particles. They weaken in succession the violet, the indigo, the blue, and even disturb the proportions of green. The transmitted light under such circumstances must pass from yellow through orange to red, and thus, while we at noon are admiring the deep blue of the sky, the same rays, robbed of their blue, are elsewhere lighting up the evening sky with all the glories of sunset.

The determination of the mechanical equivalent of heat is mainly due to the researches of Mayer and Joule. Mayer, in 1842, pointed out the mechanical equivalent of heat as a fundamental datum to be determined by experiment. Taking the heat produced by the condensation of air as the equivalent of the work done in compressing the air, he obtained a numerical value of the mechanical equivalent of heat. There was, however, in these experiments, one weak point. The matter operated on did not go through a cycle of change. He assumed that the production of heat was the only effect of the work done in compressing the air. Joule had the merit of being the first to meet this possible source of error. He ascertained that a weight of one pound would have to fall 772 feet in order to raise the temperature of one pound of water by 1° Fahr. Hirn subsequently attacked the problem from the other side, and showed that if all the heat passing through a steam engine was turned into work, for every degree Fahr. added to the temperature of a pound of water, enough work could be done to raise a weight of one pound to a height of 772 feet. The general result is that, though we cannot create energy, we may help ourselves to any extent from the great storehouse of nature. Wind and water, the coal bed and the forest, afford man an inexhaustible supply of available energy. It used to be considered that there was an absolute break between the different states of matter. The continuity of the gaseous, liquid, and solid conditions was first demonstrated by Andrews in 1862. Oxygen and nitrogen have been liquefied independently and at the same time by Cailletet and Raoul Pictet. Cailletet also succeeded in liquefying air, and soon afterward hydrogen was liquefied by Pictet under a pressure of 650 atmospheres, and a cold of 170° Cent. below zero. It even became partly solidified, and he assures us that it fell on the floor with "the shrill noise of metallic hail." Thus then it was shown experimentally that there are no such things as absolutely permanent gases. The kinetic theory of gases, now generally accepted, refers the elasticity of gases to a motion of translation of their molecules, and we are assured that in the case of hydrogen at a temperature of 60° Fahr., they move at an average rate of 6,225 feet in a second; while as regards their size, Loschmidt, who has since been confirmed by Stoney and Sir W. Thomson, calculates that each is at most one fifty-millionth of an inch in diameter. We cannot, it would seem, at present hope for any increase of our knowledge of atoms by any improvement in the microscope. With our present instruments we can perceive lines ruled on glass of one ninety-thousandth of an inch apart. But, owing to the properties of light itself, the fringes due to interference begin to produce confusion at distances of one seventy-four thousandth. Sorby is of opinion that in a length of one eighty-thousandth of an inch there would probably be from 500 to 2,000 molecules—500, for instance, in albumen, and 2,000 in water. Even then, if we could construct microscopes far more powerful than any we now possess, they would not enable us to obtain by direct vision any idea of the ultimate molecules of matter. Sorby calculates that the smallest sphere of organic matter which could be clearly defined with our most powerful microscopes would contain many millions of molecules of albumen and water, and it follows that there may be an almost infinite number of structural characters in organic tissues, which we can at present foresee no mode of examining.

APPLICATIONS OF ELECTRICITY.

Electricity in the year 1831 may be considered to have just been ripe for its adaptation to practical purposes; it was but a few years previously, in 1819, that Oersted had discovered the deflective action of the current on the magnetic needle, that Ampère had laid the foundation of electro-dynamics, that Schweizer had devised the electric coil or multiplier, and that Sturgeon had constructed the first electro-magnet. It was in 1831 that Faraday, the prince of pure experimentalists, announced his discoveries of voltaic induction and magneto electricity, which, with the other three discoveries, constitute the principles of nearly all the telegraph instruments now in use; and in 1834 our knowledge of the nature of the electric current had been much advanced by the interesting experiment of Sir Charles Wheatstone, proving the velocity of the current in a metallic conductor to approach that of the wave of light. Practical applications of these discoveries were not long in coming to the fore, and the first telegraph line on the Great Western Railway from Paddington to West Drayton was set up in 1838. In America Morse is said to have commenced to develop his recording instrument between the years 1832 and 1837. In 1851, submarine telegraphy became an accomplished fact through the successful establishment of telegraphic communication between Dover and Calais. Submarine lines followed in rapid succession, crossing the English Channel and the German Ocean, threading their way through the Mediterranean, Black, and Red Seas, until in 1863, after two abortive attempts, telegraphic communication was successfully established between the Old and New Worlds, beneath the Atlantic Ocean. Duplex and quadruplex telegraphy, one of the most striking achievements of modern telegraphy, the result of the labors of several inventors, should not be passed over in silence. It not only serves for the simultaneous communication of telegraphic intelligence in both directions, but renders it possible for four instruments to be worked irrespectively of one another, through one and the same wire connecting two distant places. Another more recent, and perhaps still more wonderful achievement in modern telegraphy is the invention of the telephone and microphone, by means of which the human voice is transmitted through the electric conductor by mechanism that imposes through its extreme simplicity. In this connection the name of Reiss, Graham Bell, Edison, and Hughes, are those chiefly deserving to be recorded. By the electric transmission of power, we may hope some day to utilize at a distance such natural sources of energy as the falls of Niagara, and to work our cranes, lifts, and machinery of every description by means of sources of power arranged at convenient centers. To these applications the brothers Siemens have more recently added the propulsion of trains by currents passing through the rails, the fusion in considerable quantities of highly refractory substances, and the use of electric centers of light in horticulture as proposed by Werner and William Siemens. By an essential improvement by Faure of the Planté secondary battery, the problem of storing electrical energy appears to have received a practical solution, the real importance of which is clearly proved by Sir W. Thomson's recent investigation of the subject. It would be difficult to assign the limits to which this development of electrical energy may not be rendered serviceable for the purposes of man.

As regards mathematics I have felt that it would be impossible for me even with the kindest help, to write anything myself. Mr. Spottiswoode, however, has been so good as to supply me with a memorandum [which the president then read. It gave a general account of the progress of mathematics. A similar memorandum was supplied by Professor Frankland on the subject of the advance of chemistry, while Captain Douglas Galton furnished the notes on improvements in mechanics].

In a complete survey of the progress of science during the half century which has intervened between our first and our present meeting, the part played by mathematics would form no insignificant feature. To those indeed who are outside its enchanted circle it is difficult to realize the intense intellectual energy which actuates its devotees, or the wide expanse over which that energy ranges.

ECONOMIC SCIENCE—EDUCATION.

If I say little with reference to economic science and statistics, it is because time, not materials, are wanting. I scarcely think that in the present state of the question I can be accused of wandering into politics if I observe that the establishment of the doctrine of free trade as a scientific truth falls within the period under review. In education some progress has been made toward a more rational system. When I was at a public school, neither science, modern languages, nor arithmetic formed any part of the school system. This is now happily changed. Much, however, still remains to be done. Too little time is still devoted to French and German, and it is much to be regretted that even in some of our best schools they are taught as dead languages. Lastly, with few exceptions, only one or two hours on an average are devoted to science. We have, I am sure, none of us any desire to exclude or discourage literature. What we ask is that, say, six hours a week each should be devoted to mathematics, modern languages, and science, an arrangement which would still leave twenty hours for Latin and Greek. I admit the difficulties which schoolmasters have to contend with; nevertheless when we consider what science has done and is doing for us, we cannot but consider that our present system of education is, in the words of the Duke of Devonshire's Commission, little less than a national misfortune.

In agriculture the changes which have occurred in the period since 1831 have been immense. The last half century has witnessed the introduction of the modern system of subsoil drainage, founded on the experiments of Smith, of Deanston. The thrashing and drilling machines were the most advanced forms of machinery in use in 1831. Since then there have been introduced the steam plow, the mowing machine, the reaping machine, which not only cuts the corn but binds it into sheaves; while the steam engine thrashes out the grain and builds the ricks. Science has thus greatly reduced the actual cost of labor, and yet it has increased the wages of the laborer. It was to the British Association, at Glasgow, in 1841, that Baron Liebig first communicated his work, "On the Application of Chemistry to Vegetable Physiology;" while we have also from time to time received accounts of the persevering and important experiments which Mr. Lawes, with the assistance of Dr. Gilbert, has now carried on for more than forty years at Rothamsted, and which have given so great an impulse to agriculture by directing attention to the principles of cropping, and by leading to the more philosophical application of manures.

I feel that in quitting Section F so soon, I owe an apology to our fellow-workers in that branch of science, but I doubt not that my shortcomings will be more than made up for by the address of their excellent president, Mr. Grant-Duff, whose appointment to the Governorship of Madras, while occasioning so sad a loss to his friends, will unquestionably prove a great advantage to India, and materially conduce to the progress of science in that country. Moreover, several other subjects of much importance, which might have been referred to in connection with these later sections, I have already dealt with under their more purely scientific aspects. Indeed, one very marked feature in modern discovery is the manner in which distinct branches of science have thrown and are throwing light on one another. Thus the study of geographical distribution of living beings, to the knowledge of which our late general secretary, Mr. Sclater, has so greatly contributed, has done much to illustrate ancient geography. The existence of high northern forms in the Pyrenees and Alps points to the existence of a period of cold when Arctic species occupied the whole of habitable Europe. Wallace's line—as it has been justly named after that distinguished naturalist—points to the very ancient separation between the Malayan and Australian regions; and the study of corals has thrown light upon the nature and significance of atolls and barrier reefs. In studying the antiquity of man, the archæologist has to invoke the aid of the chemist, the geologist, the physicist, and the mathematician. The recent progress in astronomy is greatly due to physics and chemistry. In geology the composition of rocks is a question of chemistry; the determination of the boundaries of the different formations falls within the limits of geography; while paleontology is the biology of the past.

And now I must conclude. I fear I ought to apologize to you for keeping you so long, but still more strongly do I wish to express my regret that there are almost innumerable researches of great interest and importance which fall within the last fifty years (many even among those with which our association has been connected) to which I have found it impossible to refer. Such, for instance are, in biology alone, Owen's memorable report on the homologies of the vertebrate skeleton, Carpenter's laborious researches on the microscopic structure of shells, the reports on marine zoology by Allman, Forbes, Jeffreys, Spence Bate, Norman, and others; on Kent's Cavern by Pengelly, those by Duncan on corals; Woodward on crustacea; Carruthers, Williamson, and others on fossil botany, and many more. Indeed, no one who has not had occasion to study the progress of science throughout its various departments can have any idea how enormous—how unprecedented—the advance has been. Though it is difficult, indeed impossible, to measure exactly the extent of the influence exercised by this association, no one can doubt that it has been very considerable. For my own part, I must acknowledge with gratitude how much the interest of my life has been enhanced by the stimulus of our meetings, by the lectures and memoirs to which I have had the advantage of listening, and, above all, by the many friendships which I owe to this association.

Summing up the principal results which have been attained in the last half-century, we may mention (over and above the accumulation of facts), the theory of evolution, the antiquity of man, and the far greater antiquity of the world itself; the correlation of physical forces and the conservation of energy; spectrum analysis and its application to celestial physics; the higher algebra and the modern geometry; lastly, the innumerable applications of science to practical life—as, for instance, in photography, the locomotive engine, the electric telegraph, the spectroscope, and most recently the electric light and the telephone. To science, again, we owe the idea of progress. The ancients, says Bagehot, "had no conception of progress; they did not so much as reject the idea; they did not even entertain it." It is not, I now think, going too far to say that the true test of the civilization of a nation must be measured by its progress in science. It is often said, however, that great and unexpected as the recent discoveries have been, there are certain ultimate problems which must forever remain unsolved. For my part, I would prefer to abstain from laying down any such limitations. When Park asked the Arabs what became of the sun at night, and whether the sun was always the same, or new each day, they replied that such a question was childish, and entirely beyond the reach of human investigation. I have already mentioned that, even as lately as 1842, so high an authority as Comte treated as obviously impossible and hopeless any attempt to determine the chemical composition of the heavenly bodies. Doubtless there are questions, the solution of which we do not, as yet, see our way even to attempt; nevertheless, the experience of the past warns us not to limit the possibilities of the future. But however this may be, though the progress made has been so rapid, and though no similar period in the world's history has been nearly so prolific of great results, yet, on the other hand, the prospects of the future were never more encouraging. We must not, indeed, shut our eyes to the possibility of failure; the temptation to military ambition; the tendency to over-interference by the State; the spirit of anarchy and socialism—these and other elements of danger may mar the fair prospects of the future. That they will succeed, however, in doing so, I cannot believe. I cannot but feel a confident hope that fifty years hence, when perhaps the city of York may renew its hospitable invitation, my successor in this chair—more competent, I trust, than I have been to do justice to so grand a theme—will have to record a series of discoveries even more unexpected and more brilliant than those which I have, I fear so imperfectly, attempted to bring before you this evening.

A MODIFICATION OF THE PLANTE BATTERY.

M. DE PEZZER has constructed a modification of the secondary battery of M. Planté, in which he has endeavored to obtain a maximum charge with a minimum quantity of lead. He uses for the negative electrode, a very thin lead plate of about ½ mm. thick, the positive plate being no more than 2 to 3 mm. thick; projecting portions of the plates which serve for connections are, however, somewhat thicker. Besides this, M. De Pezzer has effected another modification, based upon experiments lately made by him. He took two identical couples, each formed of two plates of lead of the same thickness, one of which, however, had twice the surface of the other. He then charged the couples by the same means, but arranged them so that in one case the plate with the larger surface should be the positive element, and in the other, the negative. By this means he discovered by repeated experiments that the couple in which the plate with the large surface was the negative electrode accumulated more electricity than the other couple. The discharge of both couples was made to pass through the same resistance, which comprised a galvanometer, and it was seen that the duration of the discharge was sensibly proportional to the charge. In four consecutive experiments the discharge of the couple with the large surfaced negative plate lasted at least an hour, while that of the couple in which the positive plate had the larger surface lasted but half an hour. Finally, a couple formed of two plates equal in size to the two large ones of the above-mentioned couples gave an inferior result to that of the couple with the large negative plate. With these results to guide him, M. De Pezzer modifies the construction of the secondary battery as follows: Preserving the sizes of the plates given above, he makes the surface of the positive half as big as that of the negative plate, at the same time making a certain number of incisions in the former. The arrangement of the plates is the same as ordinarily; but, according to M. De Pezzer, his modification is capable of storing up the same quantity of electricity as a much heavier battery constructed in the usual way. *La Lumière Electrique* says that M. De Pezzer promises exact figures on this point.—*The Electrician.*

THE HARVEY STATUE.

A STATUE of Harvey, the discoverer of the circulation of the blood, was unveiled by Professor Owen, C.B., at Folkestone, England, on the 5th of August, in the presence of a large company, including Professor Albanese (Palermo), Dr. Astley, Professor Bamberges (Vienna), Professor W. Braune, Professor Donaldson, Dr. Fornoni, Professor Gamgee, Mr. Barnard Holt, Sir Henry Hunt, Professor W. Littlejohn, Professor Macalister, Professor Moore, Professor O'Sullivan, Sir James Paget, Professor Panum, Professor Quinlan, Dr. Owen Rees, Mr. Ernest Hart, Professor Reyher, Professor Rutherford, Dr. Ranking, and Dr. Sieveking.

A luncheon was afterwards given in the Town hall, at which upwards of two hundred and fifty guests were present. The Mayor, Mr. J. B. Tolputt, presided. Professor Owen proposed "The memory of Harvey," which was drunk in silence. Sir Edward Watkin proposed the health of Professor Owen, to which that gentleman responded. The Mayor next presented Professor Owen with a complete volume of Harvey's works. Dr. Erichsen proposed the health of Sir George Burrows, Dr. Simon, Dr. Rees, Dr. Eastes, and Mr. W. G. S. Harrison, who have been connected with the memorial fund. The majority of the party returned to town in the evening by special train.

FAST PASSENGER ENGINES.

THERE is a desire in this country for a type of passenger locomotive that will haul trains not exceeding 200 tons in weight, at the rate of 50 or 60 miles an hour, over good tracks, with no very heavy grades or sharp curves, and without any material increase of the present average running expenses and cost of track repairs. This, briefly stated, is what is wanted for fast passenger, mail, and express service upon our leading railway lines. Whether engines can be devised of such improved construction as will meet this demand, under the conditions named, is a matter of a good deal of present uncertainty. The vastly increased working capacity of the locomotive since the advent of railroads has been due to improved construction. The principle of the machine is the same now as it was fifty years ago, and it is reasonable to suppose that unless the limit of development has actually been reached, there is still a margin for further improvement as respects greater speed with a given weight of train upon an adequate foundation of roadbed and track.

Upon this problem, the recent report of the Committee of the Master Mechanics' Association upon the "Best Form of Construction of Locomotives for Fast Passenger Service" throws some light. The report embodies a concise statement of the difficulties to be overcome, as derived from the experience of a number of the most capable members of that organization, and who seem to concur in the opinion that the running of fast trains with engines specially designed for the purpose is a kind of luxury which the passenger business of only a few roads in this country will justify. The reasons for this opinion are so plain that even a layman can hardly fail to appreciate their force. An engine with a single pair of driving-wheels not less than 6 feet in diameter, would seem to be the best adapted for speed—other things being equal—as compared with 4-wheel connected drivers. But the trouble is, that the "other things" are not equal, nor is it at all probable that any amount of mechanical ingenuity can make them so. The lack of adhesion with single drivers necessitates light trains, or the drivers will slip in starting. If weight enough is put on them to secure the necessary adhesion at the start, it is too much for running, and although it can be reduced somewhat by a special arrangement for changing the bearings on the equalizing beams, it still exceeds the maximum limit of what a single wheel should bear—say 15,000 pounds—and in consequence of such concentration, is severe on the journals and track.

It is manifest that special engines for fast trains are not adapted to the varying conditions of service on American roads. We must have engines suited to the prevailing curves and grades, and capable of handling light or heavy trains as occasion may require. For this, the distinctively American type, with four coupled drivers not exceeding 6 ft. in diameter, cylinders 18 × 24 or 20 × 24, and a boiler of the utmost practicable steam-producing capacity, is undoubtedly the best. The weight is fairly distributed upon journals and track; there is sufficient adhesion for starting and for overcoming grades, the strength of the present standard rail is not overtaxed, and a uniform speed of 50 miles an hour with ordinary trains, say of 200 tons, can be maintained on tracks in average good condition. To accomplish anything more than this in regular express passenger service is not practicable without an increase of cost, or in other words, lighter trains and greater proportionate wear and tear of permanent way. Let these engines be taxed with no more work than the best engines were required to perform twenty years ago, and 60 miles an hour would be a very commonplace performance. But since then their work has been doubled, with no change in gauge of track except to make it uniformly narrower, and thus prevent any lateral enlargement of fire-boxes, upon which boiler capacity so much depends; and it must also be borne in mind that the amount of train resistance per ton at a speed of 50 miles an hour is more than twice what it is at 30 miles an hour.

There is a great deal of exceptional fast running on our roads with the most approved American type of engines of recent construction. Instances are constantly occurring of the attainment of speeds very much exceeding a mile a minute. These performances show what can be done on parade, and the time may come when they will cease to be exceptional and become the rule, but not until they are made remunerative. The element of cost can not well be ignored, and until the roads can see their profits in heroic running, the brakes will be applied a little in advance of the point where the loss begins. We want high speed for express service, passengers, and mails, but not at the cost of running only half trains. The indispensable thing is not merely to run a mile a minute with two or three cars, but to do it with at least seven cars, including two or three sleepers. There are plenty of engines with four 5-ft. drivers that can get over a tolerably straight and level track as fast as prudent people wish to ride, but they must not destroy themselves and the cars and track too rapidly, or the traffic will not pay.—*National Car Builder.*

IRON STEAMSHIP MANUFACTURE.

UNDER the new German tariff, all materials intended for shipbuilding are exempt from duty, as also all materials entering into the repair or equipment of sea-going vessels. The Vulcan Works, located on the Oder, not far from Stettin, are engaged in constructing iron vessels; but notwithstanding the fostering hand of the Government, it would appear there are many natural disadvantages which operate as a drawback to any attempt to successfully compete on a large scale with the English and Scotch shipyards. Some of these, inherent in the nature of the business as well as in the soil itself, are indicated by our Consul at Stettin in his last report to the State Department. For example, it is necessary to bring the coal and iron required at the Vulcan establishment from long distances, and many of the immense machine tools have been imported from England at great cost. Pitch pine from the United States is used quite commonly for planking; while the engineering skill and mechanical ingenuity it would further appear have been greatly stimulated, if not actually supplied, by English artisans. The Consul had lately been on a tour of observation through these shipyards, but he does not seem to have been at all impressed with the quality of the work they are turning out. "The inferiority of finish and general inattention to nicety of detail," he tells us, "could not escape the eye of a lynx accustomed to the handiwork of the American mechanic." On the Oder he also noticed under construction a torpedo boat for the Chinese navy, which induces the reflection "that it is a great pity that our manufacturers should allow the Chinese authorities to come such a distance for such comparatively inferior work as can be afforded here."

Inferior workmanship, badly paid labor, t . cost of transporting material to the shipyards, and the necessity, more or less, of relying upon English marine architects for construction, are considerations which are not to be overlooked, even if they can be overcome.

On reflection, however, we do not know that, as Americans, we are in a position to criticise too closely this attempt of the Germans to develop iron shipbuilding on the paternal government plan. Burdens upon burdens have been imposed upon it, in one form or another, until, aggravated by the maintenance of restrictive navigation laws, if the phrase be allowed, its back has been broken. Still, this condition of things cannot be perpetual. We should have but a beggarly opinion of the enterprise and spirit of our countrymen if it were content that it should be perpetual. The time must come when they will be tired of having their ports practically under the domination of the British flag, and the profits of the vast and ever-extending ocean carrying trade placed to foreign account. We have the iron, coal, timber, and all other material for steamship manufacture, as likewise the engineering and mechanical skill. To utilize these we are not obliged to follow the paternal methods of either Germany or France, which practically constitute shipbuilding to a large extent a direct charge upon the public treasury. It is only necessary that our triple Government, federal, State, and municipal, should take their several hands off a badly handicapped industry, and afford American capital, American enterprise, and American skill once more an opportunity to regain their old-time position on the seas.—*New York Commercial Bulletin.*

THE MANUFACTURE OF RUSSIAN SHEET IRON.

By Mr. H. B. FROOM.

So many different versions were current as to the process adopted for producing the sheet iron known as Siberian, polished and unpolished, I determined when in the Ural to remain, if possible, at some one or more of the works, and watch the production from the ore to the finished sheets.

The manager, Ivan Ivanovitch Wohlsted, of the celebrated Demidoff Works, obligingly offered me every facility, and in the report which follows the method followed there is explained; where from observation in other works, any difference of procedure of a serious nature was noted, I mark it, but the general conclusion I came to is that the manufacture of sheet iron is carried on with great care, great labor, and expense, and that having good ore to commence with, the result is not difficult to obtain.

From the commencement to the end of the manufacture of the sheets I saw completed, I did not lose sight of the same, except they were under care; so that, as the manager said, there might be no uncertainty or quibble. The ore from which the metal is made is obtained close to the blast furnaces of the celebrated Tagil Works, from which the C C N D bars are produced. This ore is very rich, and under arrangements is also used in other works, such as Takovleff, etc., the family of the original owner, Mr. Demidoff, of that district, having by marriage and sales given over right to others to mine there. The ore scarcely contains a trace of phosphorus, and not any trace of sulphur. The analysis is as follows:

SiO_2	..	7·871
Al_2O_2	..	3·572
Fe_2O_3	..	80·047
Mn	..	—
Mn_3O_4	..	0·571
CaO	..	0·97
S	..	—
P	..	0·25

The flux used is ordinary limestone, found on the spot. Before being placed in the furnace the ore is roasted in heaps of from 10,000 to 15,000 tons, with charcoal made from *white* pine. If the iron is for sheets the workmen will not use charcoal made from *birch* wood. The roasting is done close at hand, quite in the open, and at any time of the year, the intense frost or heat not making any difference. In some works they prefer to roast the ore in the winter, and say *red* pine charcoal is not worse than white pine. The workmen assert that if charcoal made from birch wood is used, particularly in the blast furnace, then white specks are seen on the sheets. The managers say this is prejudice. The blast furnaces are oval. The size adopted as a standard has a capacity of 9,000 cubic feet; the oval is 20 ft. by 10 ft., being 52 ft. high. The bottom is 3 ft. in diameter, and at 9 ft. from bottom is full size of the oval. The system is Roshett's, with six tuyeres on each side, using hot blast at 200 degrees Celsius. The furnace is charged every half-hour with a thin layer of roasted ore and charcoal ore, broken up small and mixed with the flux; pieces of ore larger than a good-sized walnut are not passed. The blast for three such furnaces is provided by three horizontal engines, each having 29 in. steam cylinder and 5 ft. stroke. The production is 1,500 lb. to 2,000 lb. per day, 25 to 30 tons. New charcoal produces more than old, but the production varies little. The pig iron produced is at once puddled in an ordinary puddling furnace. The workmen attach importance to its being at once puddled, and make it into blooms of 100 lb. to 200 lb. weight. The puddling may be done with gas; it seems not to matter. Great care is taken to hammer the blooms well, and get rid of all impurities, under either a steam hammer or tilt hammer. Many workmen contend that the steam hammer is not so good as the tilt, but it seems simply prejudice. The blooms are at once reduced in a regular way into bars 5 in. wide, but of various thicknesses. After the bar has got rather cool the workmen stop rolling. These bars are at once cut into pieces 29½ in. and 30½ in. long, each piece representing a future sheet, and being of various thicknesses for sheets of diverse weights.

Sheet iron in Russia is invariably made 4 ft. 8 in. by 2 ft. 4 in. (2 arshines long, 1 arshine wide), and called 7 lb., 8 lb., 12 lb., or 15 lb., being made of all weights from 6 lb. to 20 lb. per sheet. Hence the thickness of the puddled bars is not much considered.

The puddled bars when broken show a fine granular fracture, somewhat steely, little if any fiber being found in the bars. About sixty of these pieces are taken—29½ in. for ordinary sheets and 30½ in. for polished or "glanced" sheets—and put into an ordinary furnace heated with wood from below, the bars being placed on ridges in the upper chamber, the flame impinging through three openings on either side. The rolling down of these bars into sheets is a matter of three processes. First, each slab is rolled out into a plate as near as possible—workmen being guided by the eye—2 ft. 6 in. by 2 ft. 8 in. Six men are engaged in this process. One man screws down the rolls to a fixed standard of thickness. There are two rollers, one man draws the slabs, and the other carries to the rolls. While these are rolling the slabs down a sorter selects them in lots of three, putting a smaller one between two larger ones, and they are thus in lots of three returned to the furnace. Secondly, these "threes" not tied together in any way, but simply assorted, again at a fair heat are drawn out and brought to the rolls, held open by the roller, and a boy throws between the plates prepared powdered charcoal; the bundles are then passed through the rolls, the rolls being screwed down to the same point as before, the thickness of the three being reduced to the same as each was previously. Now the sorter again divides the sheets into lots by thickness, and makes bundles—not tied bundles—of three of the thicker, four of medium, five of thinner, and returns them to the same furnace. Thirdly, when the bundle is again at a good heat—red cherry—these lots of plates are brought to the rolls, opened out, and charcoal again powdered all over them, and the lots are passed through the rolls, until the thickness of the lot is brought to the standard of the original one slab. The sheets are now all sheared to one length—5 ft.; in the width they are not touched. The sheets are now ready for the finishing process. Before proceeding to this, let me describe the preparation of the charcoal, a matter to which the workmen attach much importance, but which the managers do not seem to consider of any moment.

The workmen object to birch wood charcoal, and prefer yellow pine and large sized charcoal. It is first carefully washed to get out all earthy matter, ground in a mortar mill, or pounded under a hammer, washed again and dried, again pounded and sifted through a fine sieve. The workmen attach the greatest importance to using charcoal; but I saw sheets prepared without, which seemed quite as good, but the workmen contend that the sheets without charcoal soon lose the "bloom," or fresh look, especially with unpolished sheets. The sheets from the third process are stacked to cool completely—the lots I had in hand were allowed to stand in a rack from evening to morning—and are then assorted, as near as possible by the eye, into sheets of equal weight—seventy or eighty being considered a "pair" or lot for the future processes. Each sheet, being examined and brushed, is then dipped into a tank of water—the tank is never cleaned out, but kept full—"older the water the better"—and kept at about blood heat. Taken out of the bath, each plate is powdered all over with the prepared charcoal, dusted from or through a coarse linen bag. If the powdering is not done "equally" the color of the sheets will not be equal. The sheets being thus prepared, on the top and bottom of the bundle are placed two or three old plates to protect the sheets. The bundle of sheets being placed in the furnace, are very gradually heated—the workmen considering that the more smoke there is in the heating of the bundles the better the sheets will be; but to get the bundles to a bright red heat, not less than seven or eight hours should be employed. The bundles I had in hand were dipped, powdered, and prepared by 3 o'clock, and were in the furnace till 10:30—the same furnace as before described, but that on and around the bundle wood was placed to prevent direct action of the flames and produce smoke. When the packet was removed from the furnace, at a bright red heat, it was laid on a large iron slab; every sheet was turned over, brushed with a wet fir broom, and when the bundle had got to a dark red it was placed under a wrought iron tilt hammer, and received in four minutes 200 to 210 blows—the hammer weighing 45 poods (15 cwt.); after this hammering every sheet was again examined on both sides, any dirt specks removed; particular attention paid to there having been no welding.

The bundle was again made up as before, put back again into the furnace to be again reheated—this took 56 minutes. It was then again examined; again put under the hammer at a dark red and hammered for 14 minutes, receiving 750 blows. This was repeated a third, fourth, fifth, and sixth time in following sequence:

	Packed in furnace.	Under hammer.	Number of blows.
	hours min.	min.	
First as noted.	7 30	4	200
Second time.....	0 50	14½	750
Third time.....	0 30	15½	775
Fourth time.....	0 24	11	550
Fifth time.....	0 30	7	350
Sixth time	0 30	7	350
Totals.....	8 34	59	2,975

The bundle of sheets being examined by the hammer-man, is handed over to the finishers, generally between 2,500 and 3,500 blows having been given. The first thing for the finisher to do is to examine each and every sheet. A three-eighths inch or one-quarter inch plate is put on the slab, and each sheet examined; between each of the hot sheets is placed a sheet of finished iron—or two if the bundler thinks best—so that the packet becomes a bundle of from 200 to 220 sheets. It is at once taken without any reheating, and the bundle receives from sixty to eighty blows from a cast hammer on a cast iron anvil; the latter must be accurate. Note cast iron, for in the first process wrought is preferred. Having received this hammering they are called "half finished," and then the whole contents of the bundle is placed on one side to cool. This we did by letting them remain in rack all night again. The processes above noted commenced at 3 A.M., and finished at 6 o'clock P.M.; the men—six—had done nothing but work at four bundles, *i. e.*, about 300 pieces of puddled bar. I kept my eyes particularly on two bundles, which now consisted of 150 sheets. Next morning at six these 150 sheets were cut to exact selling size, 56 in. by 28 in., by hand shears, which they find to be cheaper than cutting by machine.

It will be remembered that in the last process the hot sheets were placed between cold ones; now the process was exactly reversed. Our 150 sheets were cold, a hot bundle of 150 sheets was brought, and two bundles made up, each of 75 old hot sheets and 75 new cold sheets, in process of manufacture, care being taken not to put in the hot sheets while any appearance of redness remained. These bundles were then taken again to the polishing hammer, and each received in four to five minutes 140 to 150 blows. The hammerman declared, from observing the motion of the plates, they were now ready; the bundles were opened and we found certainly fine polished sheets. The working tool sheets being removed, the new sheets were taken to the store and subjected to a thorough examination, near 30 per cent. being condemned as "brack." Taking 180 pieces of puddled bars the result was as follows: We got 160 sheets; out of these 160 we lost 12 in the first processes by holing, cracking, etc., and on reception in magazine 43 were thrown out as imperfect, from cracks, spots, or blemish in polish. The remaining 115 sheets were divided into two categories—(1) where polish was good, *i. e.*, equal all over the sheet, 67:

(2) where generally polish was good, but not entirely equal, 48. The rest were considered "brack," and sold at about £2 per ton cheaper, for makers of small articles, on the spot.

Conversing with the men, they say formerly they considered the polish was produced by the blow of the tilt hammer giving a gliding motion to the sheets; hence the name of "glance" iron. It was also held as an article of faith that after every reheating powdered charcoal must be used. This is not the case, for sheets quite as good are produced without; but the men are paid on the production, and hence the managers allow them their own way. I saw a bundle of sheets done without the charcoal and without the dipping, the results being exactly the same. The covering sheets were not much burnt, the heat of furnace being only moderate.—*The Engineer.*

DRY PLATES.

ROCHE'S MODE OF DEVELOPING THE EASTMAN GELATINE DRY PLATES.

FIRST make two stock solutions as follows:

No. 1.

A saturated solution of oxalate of potash (a pint or quart), and test with blue litmus paper; if it *does not show* an acid reaction, dissolve a little oxalic acid in water and add enough to the solution to cause the blue test paper to turn red.

This solution should be filtered before use.

No. 2.

Make a saturated solution of pure sulphate of iron, and to one quart add five or ten drops of sulphuric acid, to prevent oxidation, and filter.

Now to develop a 5×8 plate, take three ounces of No. 1, and to this add one drachm of bromide of potassium solution (which is, water, one ounce, bromide of potassium, twelve grains); then add half an ounce of No. 2. This forms the developer.

First soak the plate in *cold* water from thirty seconds to one minute; then transfer the plate to a developing dish and pour on the developer. If the picture comes out gradually and develops sufficiently, it is good so far; but if from *under*-exposure the details hang back and refuse to develop further, then add two drachms or half an ounce more of No. 2, which will bring the picture out with full details unless greatly under exposed.

Never exceed one ounce of No. 2—the *iron*—to three ounces of No. 1, for if you do you will form a sandy deposit and discontinue the action of the developer.

Always develop until the picture seems sunken into the surface; do not judge by looking through the negative only. Wash and fix in hypo, one ounce; water, eight to ten ounces. After fixing, wash well. Now, if the plate requires more intensity, flow over a solution of alum, one ounce; water, sixteen ounces; then wash. Now flow over or use in a dish, a three or five grain solution of bichloride of mercury; then wash and apply the following, which will change the color rapidly:

Water	4 ounces.
Hyposulphite of soda	40 grains.
Strong liquid ammonia	20 drops.

Now wash and let the negative dry spontaneously.

—*T. C. Roche.*

GELATINE PLATES.

AT the recent Photographers' Convention in this city, Mr. Joshua Smith, of Chicago, delivered an address on the practical working of the gelatino-bromide process, as follows:

I have been making dry plates exclusively since about the 6th of January of last year. That is all

I used to buy my plates of the manufacturer, but I have experimented a good deal and spent a great deal of time and money, and now make dry plates in my own gallery at all times. My idea was to make them when the weather was cool, and as a consequence I made a stock of five thousand; but the business increasing they were all used up the last part of last month, so I picked up the same old formula by which the previous ones had been made and everything worked smoothly.

This formula I will give; but if you make a failure I don't want you to blame me.

In the preparation of the plate the best plan is to use a substratum.

Make a solution of 60 grains of thymol in one ounce of alcohol, and take one drachm of that to the white of each egg. Make a solution of albumen by shaking up and filtering about 1 to 8. I pour that over the plates, and let them dry. My plates are now ready. I pour this on the plate while it is yet wet.

I have got in my gelatine room a marble slab two feet wide and eight feet long that is thoroughly leveled; that is on my left side. About eight inches above I have got it covered with boards so that no dust can fall on to the plates while setting. I have a leveling stand composed of three large screws in a piece of board.

In the summer time, when the thermometer is above 80 deg., it is hard to make gelatine plates, because gelatine will commence to run at 85°, or a little more, according to the moisture of the atmosphere. I take wet sheets and hang them up in my dark room, and that reduces my temperature about 3°, so I can work. I have got a large dish with a little spout on it at the bottom, to which I attach a rubber hose, and in that dish I put crushed ice, the hose being for the purpose of carrying away the water.

This is my formula: I take 300 grains of French Coignet gelatine, and wash it in several changes of water; melt at 100°. Then I go to work and make a silver solution, a bath, in fact, 60 grains strong, and I put in a pinch of carbonate of soda so as to neutralize all acidity present. I put it in the sun until it is perfectly clear. Of this I take 7 ounces. I now add 275 grains of bromide of ammonium to the gelatine, mix thoroughly, and then add the 7 ounces of nitrate of silver already referred to. This is done by placing the gelatine in a porcelain vessel in which is inserted a coarse hard rubber comb, mounted so as to be capable of being rapidly rotated by a simple handle. The silver is conveyed into the gelatine through the instrumentality of a funnel supported on a stand placed close to the porcelain vessel, a piece of rubber tubing serving to convey the liquid from the funnel to the gelatine. In this funnel the silver is slowly poured while the comb is being rotated. The temperature of the gelatine is kept all night at 120°. It is then lowered to 90°, when 350 grains of Nelson's No. 1 gelatine are added and allowed to stand for two hours and a half, after which it is poured out to set. Now wash by forcing it through a canvas into plain water, and 200 grains of Nelson's No. 1 gelatine. Melt and filter, after which it is ready for use.

In the previous preparation I place the gelatine in a half gallon preserve jar with a cork instead of the usual screwed cover, and place it in a box of water at a temperature of 120° Fahr., the heat being kept up by a gas lamp underneath. I place this in a dark room, from which I do not remove it until morning. I keep up the temperature at 120° all night. The last addition of gelatine is afterward made.

Previous to washing, the emulsion which has been allowed to set is broken up by means of a paper knife, and placed in a linen canvas, through the meshes of which it is forcibly ejected by pressure. The object of the washing is to impart a greater degree of sensitiveness by the removal of the nitrate of ammonia, which results from mixing the bromide salts with a nitrate of silver.

This is now liquefied and filtered through chamois leather previously washed with soda to free it from grease. To this I add half a drachm of a solution of chrome alum to eight ounces of emulsion. In coating the plates I employ a horn spoon, pouring the emulsion on the center and spreading it by means of the finger, tilting it wherever necessary. The plate is transferred to a marble slab, where it rapidly solidifies. When quite dry the plates are packed up in parcels and labeled with the dates of preparation. Slates so prepared are very certain and reliable.—*Photo. Times.*

THE GOLD BLUFFS AND GOLD BEACHES ON OUR NORTHERN COAST.

MORE than thirty-one years have now elapsed since the first discovery of gold in the beach sands on this coast. This occurred at Gold Bluff in 1850, and led to the excitement which, the following spring, carried a great many people to that point. Although the most of these adventurers were disappointed in their expectations, the existence of gold in considerable quantities at that locality was not altogether a myth. The precious metal was there, but it existed in a form and under conditions that made it impossible for these people to gather it with profit. So, after a few fruitless attempts at working these deposits, the business was abandoned, the most of these Argonauts returning to San Francisco, whence they came, a few having made their way farther up the coast, or crossed the mountains to the mines on Trinity River, then just beginning to be heard of.

The trouble with these beach deposits was this: The gold which the surf threw up and exposed to view at one time was covered with masses of barren sand or swept wholly away at another, its stay being too brief to permit the waiting crowd, ill equipped for the purpose, to secure more than an infinitesimal portion of it at any one time. Then, but little of the gold that the sands contained, could, by reason of its fineness and its being coated with some greasy or gaseous substance, be saved. And so Gold Bluff was, for the time being, pretty much deserted, and its name afterward classed with the traditionary humbugs of which there were all too many at that day.

But there were those who entertained the belief that where there was so much gold, means could be devised for saving at least sufficient to make the collecting of it remunerative. Of these hopeful ones enough remained to form several small companies who pursued here the business of gold gathering with tolerably good results, these parties having stopped at the original Gold Bluff, and secured there some of the best paying portions of the beach.

In course of time, however, the whole of the beach lying in front of this bluff, some eight miles in extent, fell into the hands of two companies, the one composed of two members, Greenbaum & Chapman, and the other by some six or eight persons, all practical miners. These companies adopted the plan of gathering at low tide the richest portions of the sand, and packing it on animals up beyond the reach of high water, and there washing it in sluices. As each of them owned four miles of beach, it seldom happened that they failed to find after a heavy surf, with a favorable wind, some rich sand at one point or another along this stretch of beach, and having grown expert at detecting these deposits when present, and being withal well provided with the means for securing and removing them, these companies made the business pay handsomely. But the locality being remote and difficult of approach, vessels of any kind rarely ever touching and making no regular landings there, only at long intervals have we been able to hear much about the operations of these companies, little exact information on the subject having, in fact, ever reached the public ear.

From Mr. Allen Heald, of Oakland, who is familiar with this class of deposits, and who, not long since, visited Gold Bluff, traversing the beach thence north, we have some recent and reliable information from this isolated but interesting section of our gold fields. Touching the history and operations of the two companies mentioned, it seems that they or their successors are still the only parties extensively engaged in gathering and washing the auriferous sands at or near the old Gold Bluff.

The Greenbaum Company still consists of the two members who originally composed it. The shares of the other company having been bought up by Richard Furnald and Solomon Hall, this property was afterwards sold to Adson Adams, the real estate millionaire, of Oakland, Mr. Heald having examined the ground and negotiated the sale on behalf of Mr. Adams, who is now its sole owner. Each of these estates yields on an average about $40,000 per year, of which something like 65 per cent. consists of net profits. As Mr. Adams paid but $50,000 for his purchase, he naturally considers the bargain a good one. He has since been offered $100,000 for the mine, but declined to sell at any such figure, believing it a good legacy to leave to his children. Not only so—he finds the locality a pleasant summer resort, and is, at this time, sojourning at Gold Bluff with his family.

The manner of conducting the business of gold gathering at this point is as follows: After a heavy surf the superintendent of the mine rides along the beach as the tide begins to ebb and carefully notes the condition of the sand, watching for evidence of gold having been thrown up by the waves. If he discovers that fresh deposits have been made he signals the muleteers to that effect, who then rush down their animals and pack out as much of the auriferous sand as possible before the tide again comes in and puts a stop to their work, covering up perhaps the rich streak with a heavy layer of barren sand or possibly sweeping it away altogether.

It is a singular circumstance that when the surf comes square on the beach the gold brought up by it is covered under several feet of this barren sand, and that only when the surf strikes the beach at some other angle, is the gold left on the surface where it can be seen and readily gathered. After being so collected, this rich sand is washed in sluices, small streams of water having been brought in for the purpose. For saving the gold only copper silvered plates are used in the sluices, which are usually run with a light head of water.

On the border of a small lagoon on the Greenbaum ground, a short distance back from the beach, occurs a large body of low-grade sand. This is run out on cars and washed in an old fashioned "Jenny Lind" tom, being a sluice of one box widened out and supplied with a screen at the lower end.

At one time it was thought that this gold was brought up out of the ocean, an opinion that some people still entertain. But this is clearly a mistake. It came from the bluff in the rear, which is made up of alternating strata of clay, gravel, and sandstone, the gravel strata, three or four in number, being all more or less auriferous. The action of the waves has broken down this bluff, which varies from 100 to 500 feet in height, and released the gold; the latter having afterwards been by the same agency carried seaward at least as far as low-water mark. After a very heavy surf breaking down, as sometimes happens, a portion of the bluff, the beach below is sensibly enriched, the gold by this new addition being rendered somewhat coarser than before.

This fact has suggested the utility of employing powder for breaking down and disentegrating these banks, an agent that will, no doubt, some day be used for that purpose. While the sand along this beach must under such steady and long-continued working, necessarily suffer a gradual impoverishment, this latter has not, as yet, proceeded far enough here to sensibly affect practical results, a fact due, it may be presumed, to the great width of the beach at this point and to the replenishment which the stock of workable material is constantly receiving from the caving down of the banks above. Farther north, where these favorable conditions did not exist, the gold-bearing beaches have been so nearly exhausted, that hardly any work is now being done, where, from fifteen to twenty-five years ago, thousands of men made good wages.

That the sand, which is constantly covered by the sea, is not very rich has been proven by the trials made on it some years ago with steam dredgers, none of which found gold enough in it to warrant a continuance of these operations.

Each of the companies above mentioned employ from ten to twelve men and about eighteen pack-animals the year round. Operations are kept up with but little interruption, the men being engaged a good part of the time, either in gathering sand or washing it. What time they are not so employed is devoted to cultivating a patch of land in the neighborhood, on which the companies raise some fruits, hay, and vegetables for their own use.

Adjoining the Adams claim, which covers the upper or northern half of the beach, a small company is washing these sands by the hydraulic method, using a limited amount of water under a pressure of eighty or ninety feet. From this point north, clear into Oregon, a distance of thirty or forty miles, very little in this line of mining is being done, though this was at one time along miles and miles of the beach in the vicinity of Whisky Run and the Coquille rivers, an active and profitable industry. Here and there a small company is still to be seen reworking the sands that have already been washed, in some instances several times over, and always with remunerative results, the first one or two washings having generally paid very large wages.

From Mr. Heald, who is himself an experienced, successful miner, we learn that the present has been a prosperous year with hydraulic miners along both the Trinity and Klamath rivers, notwithstanding the water season there, as elsewhere throughout California, has been a very short one. Owing to its freedom from the vexatious *débris* question and to the presence of good conditions generally, that region of country is strongly attracting the attention of capitalists and others inclined to invest in this branch of mining. Besides great quantities of good gravel, the Klamath country is especially well situated as regards water, which is not only abundant but can be brought upon the mines at small cost and under great pressure, the mountains, the sources of the supplying streams, rising to a great height directly over the mines. That but little trouble is encountered there from high-rim rock or cemented gravel, may be inferred from the fact that no bank blasting has ever been practiced nor has a single bedrock tunnel of any length ever been driven in Klamath county; and this, notwithstanding hydraulic mining has been carried on there extensively and successfully for many years. For these and other reasons it costs comparatively little to open up and run a mine of this kind anywhere in this northern region.—*Min. and Sci. Press.*

THE CENSUS OF CANADA.

AN approximate statement has been officially made of the census of Canada last April. The population of the Dominion exhibits within the past decade an increase, by annexation and natural means, of 865,172, and now numbers 4,350,933 souls. The population of Ontario has increased to 1,913,460; of Quebec to 1,358,469; of Nova Scotia to 440,585; of New Brunswick to 321,129. The population of Prince Edward Island is placed at 107,781, and of Manitoba at 49,500. British Columbia and the Territories are estimated at 160,000, making the grand total for the Dominion of Canada of a population of 4,350,933.

The following is a comparative statement of the increase by Provinces during the past two decades:

Province.	1881.	1871.	1861.
Ontario	1,396,091	1,620,851	1,913,460
Quebec	1,111,566	1,191,516	1,358,469
New Brunswick	252,047	285,594	321,129
Nova Scotia	330,857	387,800	410,585
	3,090,531	3,485,761	4,033,643

At the time of entering the Confederation the population of Prince Edward Island was stated at 90,000; to-day it is placed at 107,781. The population of Manitoba and the North-west Territories and British Columbia, for the year 1871, has been variously estimated, but it may be placed (including Indians) at 45,000; to-day the population of Manitoba alone is placed at 49,500, and that of British Columbia and the North-west Territories at 160,000, making a total of 209,500. As compared with the census of 1871, Ontario shows the largest increase, the percentage being 18·05; Quebec, 14·02; Nova Scotia, 13·61; New Brunswick, 12·44, Prince Edward Island, 14·03. The effect of this will be to prevent any material increase in the representation of the maritime Provinces in the readjustment for the next Parliament. During the ten years the population of the four Provinces, Ontario, Quebec, New Brunswick, and Nova Scotia, have increased 547,882. A remarkable feature is the relatively large increase of Quebec, accounted for by the method of taking the census, which, the *Toronto Globe* says, includes tens of thousands who are in the United States, but who are counted members of Quebec families.

RULES OF LAWN TENNIS.

Adopted by the U. S. N. L. T. A.

THE court is 27 feet in width and 78 feet in length. It is divided across the middle by a net, the ends of which are attached to the tops of two posts, A and A, which stand 3 feet outside the court on each side. The height of the net is 4 feet at the posts and 3 feet at the center. At each end of the court, parallel with the net, and at a distance of 39 feet from it, are drawn the *base-lines*, C D and E F, the extremities of which are connected by the *side-lines*, C E and D F. Half-way between the side-lines, and parallel with them, is drawn the *half-court line*, G H, dividing the space on each side of the net into two equal parts, called the *right* and *left courts*. On each side of the net, at a distance of 21 feet from it, and parallel with it, are drawn the *service lines*, X X and Y Y.

In the three-handed and four-handed games the court is 36 feet in width, and the height of the net at the posts 4 feet (see next page). Otherwise the court is as above.

1. In the single-handed game the height of the net at the posts is reduced to 4 feet (the height of 3 feet at the center being maintained as before), and the service-line is brought into the distance of 21 feet from the net (instead of 22 feet).

2. The limits of variation in the size and weight of the balls have been reduced; they must now only vary from 2½ to 2 7/8 inches in diameter, and from 1¾ ounces to 2 ounces in weight.

The executive committee of the United States National Lawn Tennis Association shall approve the ball or balls to be used in all matches and tournaments played under the rules of the association.

3. A rule has been introduced, providing that "in matches where umpires are appointed their decision shall be final.'

4. It has been attempted to define more strictly than before the position in which the server must stand when delivering the service, viz., "with one foot beyond (*i. e.*, further from the net than) the base-line, and with the other foot within or upon the base-line."

5. It is now distinctly laid down that if the server does not stand as directed in the above law, or if he delivers the service from the wrong court, it is a fault; but

6. It is provided that having served from the wrong court, and so made a fault, he shall deliver the next service from the court from which he should have served before; and,

7. It is further provided that "a fault may not be claimed after the next service has been delivered."

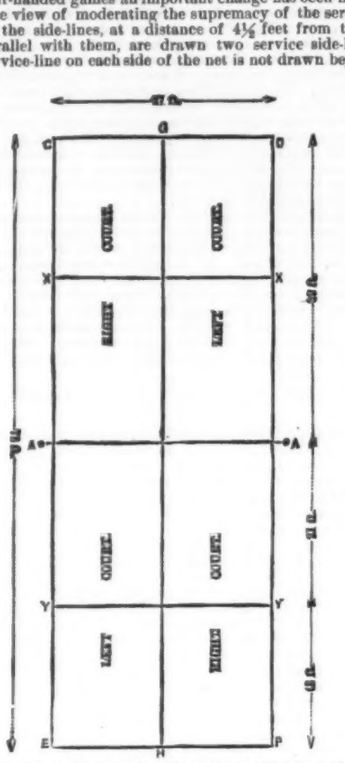
8. The law that a good service, delivered when the striker-out is not ready, annuls a previous fault, is repealed; and a service, whether good or a fault, so delivered will in future count for nothing.

9. A return in which the ball touches the net is still considered good; but "if the ball served touch the net, the service, provided it be otherwise good, counts for nothing."

10. It is expressly forbidden to either player to "touch the net or any of its supports while the ball is in play," and also to "volley the ball before it has passed the net, on penalty of losing the stroke."

11. An alteration has been made in the law affecting the change of sides at the end of each set, by which "the umpire, on appeal from either party, before the toss for choice, may direct the players to change sides at the end of every game, if, in his opinion, either side have a distinct advantage, owing to the sun, wind, or any other accidental cause; but if the appeal be made after a match has been begun, the umpire may only direct the players to change sides at the end of every game of the odd and concluding set."

12. In the laying-out of the court for the three-handed and four-handed games an important change has been made with the view of moderating the supremacy of the service: within the side-lines, at a distance of 4½ feet from them, and parallel with them, are drawn two service side-lines. The service-line on each side of the net is not drawn beyond



PLAN OF COURT FOR SINGLE-HANDED GAME.
Scale, ½ in. to a Yard.

the points at which it meets these service side-lines. By this arrangement the server will have precisely the same area to serve into in the three-handed and four-handed games as in the single-handed game, and his partner will not have so great an advantage as hitherto in standing close up to the net. On all asphalt and cement floors, where the single-handed and four-handed courts are laid out together, the one overlying the other, these inner side-lines already exist, as also on many lawns which are not large enough to allow space for both kinds of court separately. Of course, the service must be delivered so that the ball shall fall within or upon these new lines, or it will be a fault.

It will be observed, also, that the height of the net at the posts will now be the same in the single-handed and in the three-handed and four-handed games—another element of simplicity.

13. The choice of sides and the right of serving during the first game shall be decided by toss; provided that, if the winner of the toss choose the right to serve, the other player shall have the choice of sides, and *vice versa*. The players shall stand on opposite sides of the net; the player who first delivers the ball shall be called the *server*, the other the *striker-out*. At the end of the first game the striker-out shall become server, and the server shall become striker-out; and so on, alternately, in the subsequent games of the set.

14. The server shall stand with one foot outside the base-line, and shall deliver the service from the right and left courts alternately, beginning from the right. The ball served must drop within the service-line, half-court line, and side-line of the court, which is diagonally opposite to that from which it was served, or upon any such line.

15. It is a *fault* if the ball served drop in the net, or beyond the service-line, or if it drop out of court, or in the wrong court. A fault may not be taken. After a fault the server shall serve again from the same court from which he served that fault.

16. The service may not be *volleyed*, *i. e.*, taken before it touches the ground.

17. The server shall not serve until the striker-out is ready. If the latter attempt to return the service, he shall be deemed to be ready.

18. A ball is *returned* or *in play* when it is played back over the net before it has touched the ground a second time.

19. The server wins a stroke if the striker-out volley the service; or if he fail to return the service or the ball in play; or if he return the service or ball in play so that it drop outside any of the lines which bound his opponent's court; or if he otherwise lose a stroke, as provided by Law 10.

20. The striker-out wins a stroke if the server serve two consecutive faults, or if he fail to return the ball in play; or if he return the ball in play so that it drop outside any of the lines which bound his opponent's court; or if he otherwise lose a stroke, as provided by Law 21.

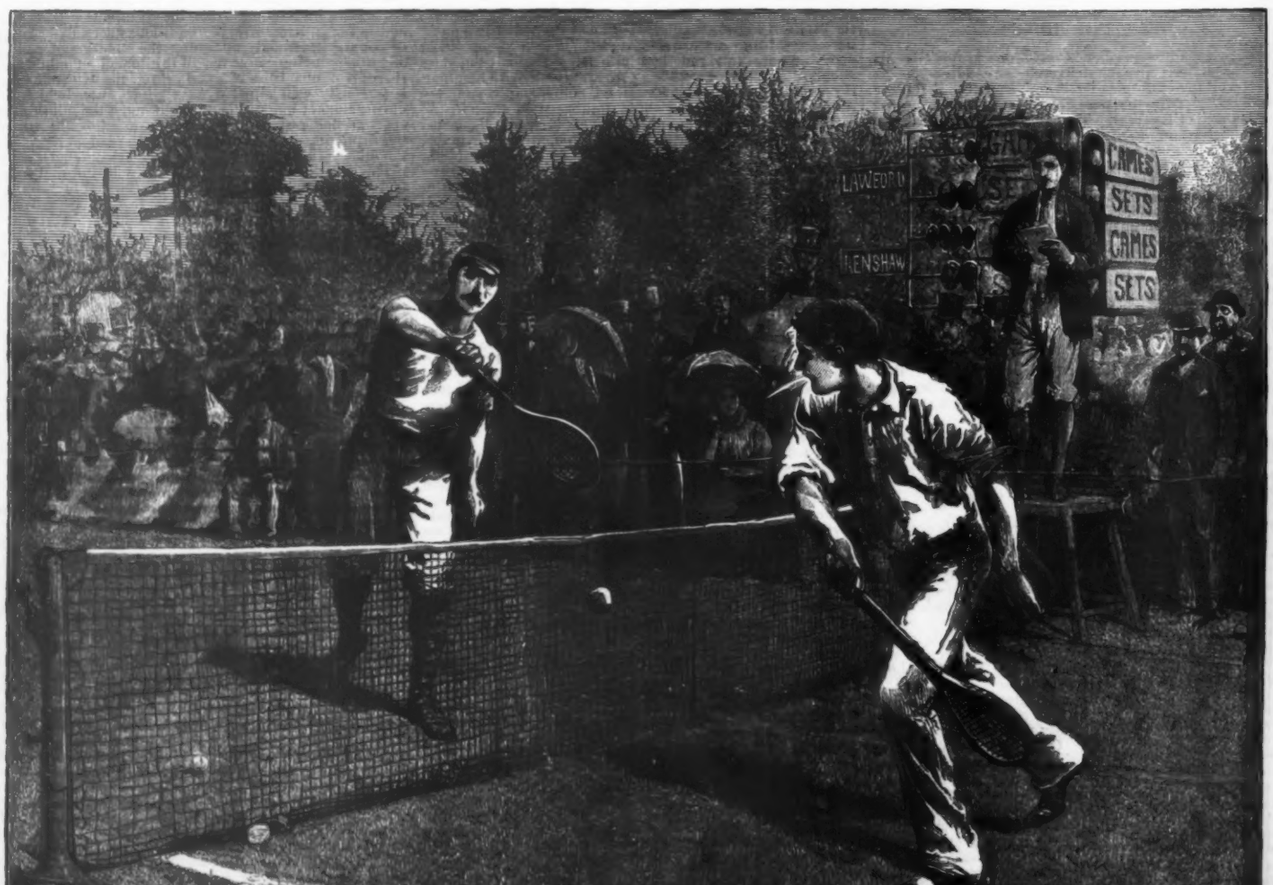
21. Either player loses a stroke if the ball in play touch him or anything that he wears or carries, except his racket in the act of striking; or if he touch or strike the ball in play with his racket more than once.

22. On either player winning his first stroke the score is called 15 for that player; on either player winning his second stroke the score is called 30 for that player; on either player winning his third stroke the score is called 40 for that player; and the fourth stroke won by either player is scored game for that player, except as below:

If both players have won three strokes the score is called deuce; and the next stroke won by either player is scored advantage for that player. If the same player wins the next stroke he wins the game; if he loses the next stroke the score is again called deuce; and so on until either player win the two strokes immediately following the score of deuce, when the game is scored for that player.

23. The player who first wins six games, wins a set, except as below:

If both players win five games the score is called games-



THE LAWN TENNIS MEETING AT WIMBLEDON.

all; and the next game won by either player is scored advantage-game for that player. If the same player wins the next game he wins the set; if he loses the next game the score is again called games-all; and so on until either player win the two games immediately following the score of games-all, when he wins the set.

NOTE.—Players may agree not to play advantage-sets, but to decide the set by one game after arriving at the score of games all.

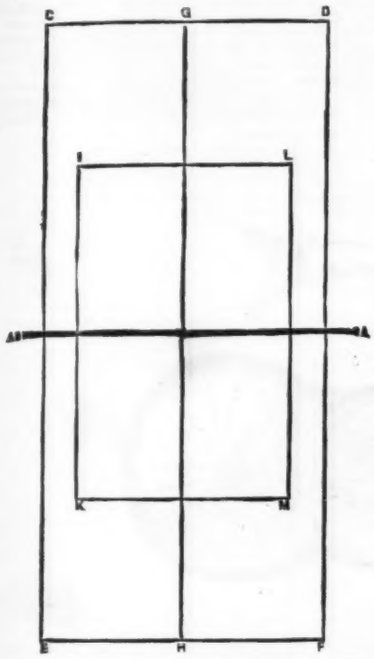
24. The players shall change sides at the end of every set. When a series of sets is played, the player who was server in the last game of one set shall be striker-out in the first game of the next.

THE THREE-HANDED AND FOUR-HANDED GAMES.

25. The above law shall apply to the three-handed and four-handed games, except as below:

In the three-handed game the single player shall serve in every alternate game.

In the four-handed game the pair who as the right to serve in the first game may decide which partner shall do so, and the opposing pair may decide similarly for the second game. The partner of the player who served in the



PLAN OF COURT FOR THREE AND FOUR HANDED GAMES.
Scale, ¼ in. to a Yard.

first game shall serve in the third; and the partner of the player who served in the second game shall serve in the fourth; and so on, in the same order, in all the subsequent games of a set or series of sets.

The players shall take the service alternately throughout each game; no player shall receive or return a service delivered to his partner; and the order of service and of striking-out, once arranged, shall not be altered, nor shall the strikers-out change court to receive the service before the end of the set.

AN ALTERNATIVE METHOD OF SCORING.

26. The above laws shall apply to lawn tennis played by the game, except as regards the method of scoring. The word *hand-in* shall be substituted for *server*, and *hand out* for *striker-out*.

27. The hand-in alone is able to score. If he lose a stroke he becomes hand-out, and his opponent becomes hand-in, and serves in his turn.

28. The player who first wins 15 points scores the game.

29. If both players have won 14 points the game is *set to* 3. The score is called *love-all*. The hand-in continues to serve, and the player who first wins 3 points scores the game.

30. In the three-handed or four-handed game, only one partner of that side which is hand in shall serve at the beginning of each game. If he or his partner lose a stroke the other side shall be hand-in.

31. During the remainder of the game, when the first hand-in has been put out, his partner shall serve, beginning from the court from which the last service was not delivered; and when both partners have been put out, then the other side shall be hand-in.

32. The hand-in shall deliver the service in accordance with Laws 14 and 15; and the opponents shall receive the service alternately, each keeping the court which he originally occupied. In all subsequent strokes the ball may be returned by either partner on each side.

33. One or more points may be given in a game.

34. The privilege of being hand-in two or more successive times may be given.

35. Half-court: The players having agreed into which court the giver of the odds shall play, the latter loses a stroke if the ball returned by him drops outside any of the lines which bound that court.

THE GROUND AND IMPLEMENTS.

Any tolerably firm level surface will answer the purpose of a *ground*; turf, concrete, or hard asphalt is the most pleasant to play on.

The *court*, *i. e.*, the part of the ground marked out for play, is 27 feet in width and 78 feet in length. It is divided across the middle by a *net*, the ends of which are attached to the tops of two *posts*, A A (see diagram, which stand 3 feet outside the court on each side.

The height of the net is 4 feet at the posts, and 3 feet at the center.

At each end of the court, parallel with the net, and at a distance of 39 feet from it, are drawn the *base-lines*, C D and E F (see plan of court for single-handed game), the extremities of which are connected by the *side-lines*, C E and D F. Half-way between the side-lines, and parallel with them, is drawn the *half-court line*, G H, dividing the space on each side of the net into two equal parts, called the *right* and *left* courts. On each side of the net, at a distance of 21 feet from it, and parallel with it, are drawn the *service lines*, X X, Y Y.

In the three and four handed games the court is 36 feet in width. Within the side-lines, at a distance of 4½ feet from them, and parallel with them, are drawn the *service side lines* (see plan of court for four handed game), I K, L M. In other respects the court is the same as in the single-handed game.

The *court-lines* on turf are best marked with whitewash. If a very small quantity of lampblack is added the lines show brighter. The lines should be about an inch and a half wide. To mark the lines accurately, first measure the distances, by means of an angle square, then peg down a string from corner to corner, and run a lawn tennis marker over the string. To make the lines very bright run them over again in the reverse direction after they are dry.

On concrete or asphalt the lines should be painted, or white bricks, placed on edge, should be built in when the court is being constructed.

The *posts* should be made of ash or hickory. They should be 4 feet in height above the ground, and about 2 inches in diameter. They may be fixed by means of guy ropes.

The *net* should be made of strong white twine. The net should descend to and lie on the ground. It should be tied to the posts at intervals of about 6 inches.

To keep the net at a uniform height in the middle, a stout iron hook may be driven into the ground midway between the two posts, and a string of the requisite length tied to the net cord, and looped into the hook.

The *rackets* should be similar in shape to the racket used at the game of tennis, weighing from 11 to 16 ounces, and about 27 inches in length.

The balls should be of hollow India-rubber of good quality; of not less than 2½ inches nor more than 2⅝ inches in diameter; and not less than 1¾ ounces nor more than 2 ounces in weight. They should be covered with strong white cloth, cemented on to the rubber, and then sewn as real tennis balls are sewn.

Covered balls when dirty may be cleaned by brushing with warm soap and water. They should then be well rinsed in cold water, squeezed, and put to dry in a warm (but not hot) place.

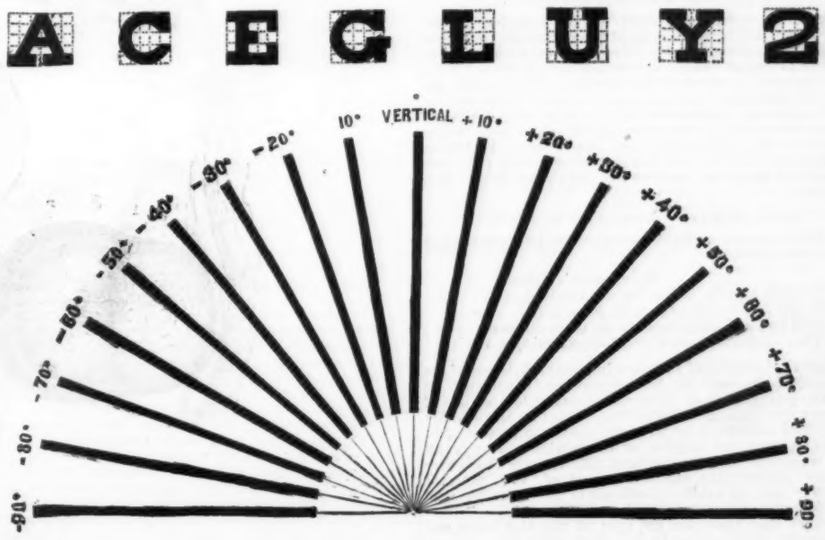
A SO-CALLED HERMAPHRODITE.

THERE is now in London a young Frenchman who presents peculiarities alike interesting physiologically and anatomically, and distressing socially. The child of healthy Parisian parents, there was nothing peculiar noticed about him as an infant; he was believed to be a female, and named, registered, and dressed accordingly. At about the age of eight years some suspicion arose that the genital organs were peculiar for a girl, but no special notice was taken. As a child he played more freely with his brothers than his sisters, and liked bicycling and riding horseback and boyish sports. Later he went to a girl's boarding-school, where he stayed till sixteen years of age. He is now twenty, and dresses as a woman, and his appearance in that attire is not in any way striking. The face is smooth and plump, with no sign of beard or whiskers, but a very few fine and short hairs are growing from the extremities of the upper lip as in a boy of fourteen. The growth of hair from the scalp is luxuriant and reaches below the waist. He asserts that no means of stimulating this growth has been adopted, and speaks of the trouble of constantly having to cut it. The voice is neither markedly masculine nor feminine; the larynx is small, the thyroid cartilage is not prominent, and has all the outward characters of that of a woman. The mammæ are well, not largely, developed, and glandular structure is distinctly to be felt; the nipple is fairly well formed, and pinkish in color. There is a very scanty growth of dark hair in each axilla. The pubic hair is abundant, but does not extend up toward the umbilicus in the middle line. There is a distinct penis about two inches long, with a well-formed glans, and the meatus urinarius is represented by a dimple. The prepuce forms a kind of cowl over the glans, and is wanting below. The scrotum is completely divided along the middle line, and in each half is a well-developed testicle, with a normal epididymis and spermatic cord. On separating the two halves of the scrotum the opening of the urethra is exposed at the root of the penis, funnel-shaped, and easily admitting the little finger as far as the membranous urethra; a catheter passes readily along it into the bladder. On the inner side of each scrotal half, and close to the orifice of the urethra, is a muco-cutaneous fold very like a nympha. The perineum is long, like that of a male. By rectal examination the outline of the prostate is readily defined. The thighs and legs are distinctly of the masculine type, as is the gait; the arms are also those of an unathletic man, and the hands are large. He has good health, but requires a good deal of exercise to keep well. He asserts that he has no exclusive preference for either sex, and that he has been in love with both men and women. There is the usual evidence of functional activity of the testicle. The associates of this man speak of his general demeanor as masculine, though occasionally markedly feminine, and they often say of him that "she is a good boy." Of course, there is no question as to the sex of this individual; he is a man with hypospadias. The special features of his case are the development of the breasts, the growth of hair from the head, the hairless face, and small larynx. It is not strange that in infancy he should have been taken for a girl, for with the smaller size of all the external genitals, the resemblance to the female sex must have been very close. It is an interesting question how far the resemblance in character to a woman—such as it is—is due simply to his education and constant association with women, or how far it is dependent upon some original peculiarity similar to that seen in the development of the mammæ and hair.—*Lancet*.

ASTIGMATISM.

By C. A. BUCKLIN, M.D., New York.

THE cornea of man should be nearly spherical. It sometimes happens that it is of a decidedly ovoid form, which necessitates the curve in one meridian being considerably sharper than the other. The cornea being a portion of a lens system which casts a distinct image of observed objects upon our retina, it is readily seen that, in the meridian having the sharpest curve, the rays of light will be acted upon more strongly than in the meridian which has a flat curve; consequently, an observed object is confused and distorted in the direction of the *sharp corneal curve*, thus: The sharp curve of the cornea being in the vertical meridian, a pin-hole in a card through which light comes to us will appear *vertically oval*, and will only appear *nearly* round when the observed opening is made sufficiently oval in the horizontal meridian to correspond with its magnified diameter in the vertical meridian. I find many who were supposed to be afflicted, "*disease of the optic nerve*," "*imperfect entrance of the optic nerve*."*



"*Amaurosis*," "*amblyopia*," etc., are suffering from the optical effects of a faulty cornea *usually* causing regular astigmatism.

The irregularities in our crystalline lens is the commonest cause of what is called *irregular astigmatism*, an optical defect which is not correctible, which we all have to a greater or less extent, and without which we would all be able to see the moons of Jupiter with our naked eye. *Mechanics* are frequently found who can never file anything square; an opening or piece of metal which is square appears longer in one direction than the other, and it is not till the piece of metal *is longer* in the direction of the flat corneal nerve that it appears square. Artists and students, and all classes who use their eyes constantly, frequently suffer from this defect.

Failing to receive any benefit from simple spherical lenses, they naturally suppose that their eyes are diseased. These individuals make the lives of spectacle-sellers uncomfortable by their constant *unsuccessful* efforts to obtain glasses. They dislike to look at striped goods, particularly when the abnormal curve lies in any of the quadrants between the horizontal and vertical meridians. It is particularly difficult for them to read in the evening, and they are constantly making remarks about how poorly they see without a very strong light.

The diagnosis of astigmatism is usually readily made if one is suspecting it. It almost invariably reduces the acuteness of distant vision. The line of letters here given should be read at twenty feet at least with the greatest ease. It is the universal standard for testing distant vision.

At the most distant point at which these letters are *perfectly* distinct, the radiating lines should all appear equally *dark* and *distinct*. If the vertical curve of the cornea is the sharpest, the horizontal lines will appear magnified and blacker until the vertical curve becomes so sharp that the magnification of the horizontal lines blur them. The vertical lines will then retain their natural thickness and remain distinct, but are never magnified under these circumstances; it is only when the horizontal curve is the sharper one that the vertical lines may be magnified. A given meridian of the cornea being abnormally flat, the rays of light falling on this meridian will be united behind the retina; conse-

* The above condition was really given as a diagnosis by an ophthalmoscopist. If such a condition exists there is nothing known about it.

quently, lines whose *thickness* is estimated by this meridian are indistinct.

The flat corneal curve being the horizontal meridian, the *horizontal* lines will be the blackest.

Persons who can read the above letters with ease at twenty feet, to whom the radiating lines all appear equally dark, and who still have weak vision caused by astigmatism, are very rare.

Persons who are quite far-sighted are obliged to accommodate strongly for distant objects, and do not show their astigmatism till the *unusual* amount of accommodation is forcibly dispensed with by giving convex lenses, which neutralize their hyperopia. They are thus prevented from compensating for the faulty structure of their corneas by changing the form of their lenses.

I have observed one case (and I think the only one observed) where, owing to a choroiditis, the rods and cones of the retina had been sufficiently separated to produce the phenomena of "*small vision;*" the horizontal dimensions of objects were particularly small; a cylindrical lens with axis vertical greatly improved the vision, and was of most decided relief to the patient.

The fact that at the most distant point at which the square letters can be read, the radiating lines do not look equally black, is good ground for supposing that reduced acuteness of vision or weak vision is caused by faulty corneal curves.

The defect is corrected in the following manner: Where the vertical curve is too sharp, a piece of glass ground on the convex surface of a cylinder is placed before the eye with the axis horizontal; such a lens acts only upon rays of light in the vertical meridian, and can be ground with just the required curve to compensate for the abnormally sharp corneal curve.

When the horizontal meridian is too flat, a piece of glass ground on the concave side of a section of a cylinder is placed before the eye with the axis vertical. Other visual imperfections may be corrected at the same time by grinding on the other side of the cylindrical lens the requisite lens.

How these radiating lines appear to an astigmatic person may be readily seen by pressing upon the upper part of the eye ball with the fingers sufficiently to increase the vertical curve of the cornea.—*Medical Record.*

THE EYE-LIKE SPOTS IN FISHES.

By Professor F. Jeffrey Bell, M.A.

We are so naturally inclined to take ourselves as the norm or standard in animal organization, that we are almost too easily astounded by any difference in the arrangement of parts or organs which are found in ourselves. With none, perhaps, is this more the case than with the eye; we are so accustomed to associate a pair of eyes with every living creature, that blindness on the one hand, or a number of eyes on the other, excites more astonishment than the reduction or multiplication of any other part. A child in spectacles is the object of a not always respectful pity; and the poet, to heighten the horror of his Cylops, makes him one-eyed.

"Ingens, quod torva solum sub fronte latebat."*

And Milton has put much the same feeling into words when he makes Samson say:

"Why was this sight
To such a tender ball as the eye confined,
So obvious and so easy to be quenched;
And not, as feeling, through all parts diffused,
That she might look at will through every pore?"

A survey, however, of the more important divisions of the animal kingdom need not be very elaborate to convince us that the arrangement of parts which obtains in the case of our own eyes, and, in broad outline, in that of all the other vertebrated animals, is by no means similar to what we find in the octopus, the crayfish, or the marine worm; yet all these three representatives of these different types have eyes of very considerable complexity and of very different ancestry; and all exhibit obedience to the same physical laws, and present similar optical conditions.

Simpler than these are the eyes of the star-fishes, and still simpler those of the leech and of the lowlier worms, some of which have, as it seems, nothing more than mere pigmented spots, the nervous supply of which has still to be worked out.

But the diversity does not end here: the leech has ten "eyes." Some of the marine worms that live in tubes have a number of eyes on the delicate respiratory filaments which project from their anterior end; some have eyes at the hinder end of their body; and *Polyophthalmus* is a veritable Argus, for in addition to the eyes in its head there is a pair on every segment of the body.

Where so much variation is seen it is only natural to expect that external conditions will be found to have very considerable influence. We all know that the earth-worm is without eyes; and to the various known examples of the reduction of the eyes in such burrowing animals as the mole, and the complete blindness of some that live in caves, such as the blindfish (*Amblyopsis*) of the Mammoth Cave, of Kentucky, and the amphibian *Proteus* of the caves of Carniolia, there have lately been added two blind snails from the just-named Austrian grotto.

The great increase in our knowledge of animals which has resulted and is resulting from the deep-sea explorations which have been carried on with such activity during the last few years is very strikingly shown in the case of the organ of sight. In one of the earliest of these—that of the porcupine—a crustacean (*Ethusa granulata*), was discovered living at various depths; specimens taken in shallow water were found to have eyes of the usual character; those which were brought up from depths varying between 110 and 370 fathoms had the ordinary eye-stalks, but the place of the eye was taken by a calcareous knob; the condition was one to which the words of Mr. Darwin may well be applied: "The stand for the telescope is there, though the telescope with its glasses has been lost." Specimens of the same species taken from still greater depths (from 500 to 700 fathoms) exhibited a still more remarkable change; the eye-stalk was found to have lost its special character, and to have been converted into a pointed rostrum. So again a number of new blind Crustacea have been lately described by M. Milne-Edwards from the Gulf of Mexico. Did the matter end here it would be easy enough to ascribe the changes to the disuse of the eye, owing to the want of light at so great a depth. Fortunately, however, naturalists were spared too hasty a generalization, for from the same depths the dredge of the same ship brought up specimens of the genus *Munida*, in which the eyes were developed to a very great size.

What is true of crustaceans is true also of fishes, as the following quotation from Dr. Gunther will show better than any words of ours: "The organ of sight is the first to be affected by a sojourn in deep water. Even in fishes which habitually live at a depth of only eighty fathoms, we find the eye of a proportionately larger size than in their representatives at the surface. In such fishes the eyes increase in size with the depth inhabited by them, down to the depth of 200 fathoms, the large eyes being necessary to collect as many rays of light as possible. Beyond that depth small-eyed fishes as well as large-eyed occur, the former having their want of vision compensated for by tentacular organs of touch, while the latter have no such accessory organs, and evidently see only by the aid of phosphorescence. In the greatest depths blind fishes occur with rudimentary eyes and without special organs of touch." *

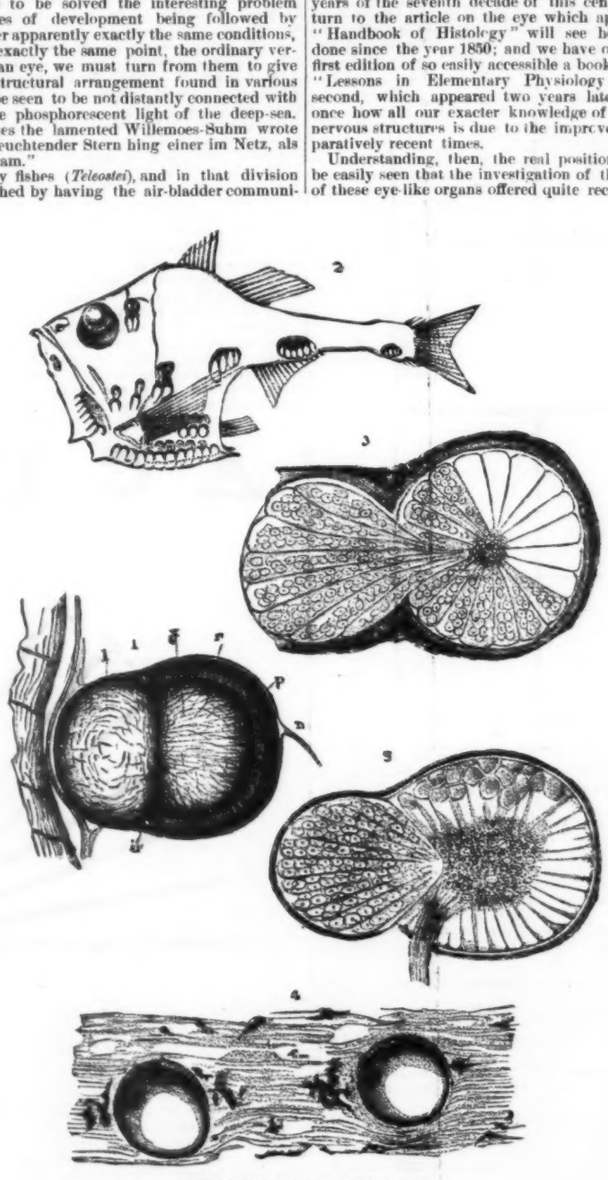
Interesting as these cases are, and that the more because there still remains to be solved the interesting problem raised by two lines of development being followed by animals living under apparently exactly the same conditions, and starting from exactly the same point, the ordinary vertebrate or crustacean eye, we must turn from them to give an account of a structural arrangement found in various fishes, which will be seen to be not distantly connected with the question of the phosphorescent light of the deep-sea. Of one of these fishes the lamented Willemoes-Suhm wrote home: "Wie ein leuchtender Stern hing einer im Netz, als er Nachts herauf kam."

Among the bony fishes (*Teleostei*), and in that division which is distinguished by having the air-bladder communicating by an air-duct with the anterior portion of the intestine (*Physostomi*), and especially among the members of the group which always, or generally, live at great depths, there are sometimes found—as for example in *Scopelus* or *Astronesthes*—one or two rows of small rounded bodies, which are chiefly distributed along the sides of the body, although sometimes, as in the latter of the two just-named genera, they are also very well developed in front of the proper eye. In *Ipnops*, a form first collected by the officers of the Challenger exploring voyage, and which is placed by Dr. Günther next to *Scopelus*, there are indeed none of these bodies; but the eye of this fish appears to have lost its function and to have taken on that of a phosphorescent organ.

Although it is only quite lately that these organs have attracted any especial attention, their presence in *Scopelus* and other forms was long ago noted by various observers. It was in the year 1839 that the Italian naturalist, Cocco, of Messina, had his attention directed to them, and he published figures and descriptions of the forms which live in the Mediterranean; ten years later a number of the species which possess these structures were treated of in the twenty-second volume of that monument of industry and research, in which Cuvier and Valenciennes systematized our knowledge of the group of fishes. But the work begun by the two, and carried on after Cuvier's death as far as the twenty-second volume, could not, even with its scope, deal in detail with all the parts of every fish; and even had that been possible, the means of investigation which were to hand would doubtless have been insufficient for a complete and correct understanding of the organization of these parts. Modern methods in histology were above all things necessary; even in the case of the human eye, we know that much of what is now the common property of all students resulted from the studies of Max. Schultze in the middle years of the seventh decade of this century. He who will turn to the article on the eye which appears in Stricker's "Handbook of Histology" will see how much has been done since the year 1850; and we have only to compare the first edition of so easily accessible a book as Prof. Huxley's "Lessons in Elementary Physiology" (1866) with the second, which appeared two years later, to recognize at once how all our exacter knowledge of these complicated nervous structures is due to the improved methods of comparatively recent times.

Understanding, then, the real position of affairs, it will be easily seen that the investigation of the minute structure of these eye-like organs offered quite recently an altogether unexplored field of research. With the exception of a short notice by Prof. Leuckart, in the year 1865, which led to the belief that the parts in question were accessory organs of sight, nothing seems to have been published with regard to them till the year 1879, when Dr. M. Ussow, of the University of St. Petersburg, gave to the world an account of his researches. These had been undertaken on twelve species, belonging to the seven genera, *Astronesthes*, *Stomias*, *Chauliodus*, *Scopelus*, *Maurolicus*, *Gonostoma*, and *Argyropelecus*, all of which are small, and most of which live in the Mediterranean. He pointed out that the organs might be arranged in two series, one of which he regarded as forming accessory eyes, and the other as special glandular organs, and he insisted on the fact that, though they are both arranged in just the same way, the two sets are never found in the same fish.

Before proceeding any further with Dr. Ussow's views, it is necessary to state that early in the year 1880 Dr. Gunther gave to the Linnean Society an account of these bodies, in which he expressed his belief that these organs were producers and not receivers of light; and in his introduction to



EXPLANATION OF FIGURES.

Fig. 1. Longitudinal section of eye of *Stomias anguilliformis* × 280, showing the inner vitreous body, *x*, and the anterior chamber with its transparent lens, *l*; *r*, retina; *n*, nerve; *p*, pigmented layer; *i r*, "iris-like" constriction. (Ussow, Fig. 10 B.)

Fig. 2. Figure of *Argyropelecus hemigymnus* × 2. (Leydig, i. 5.)

Fig. 3. Longitudinal section of organ from abdominal region of ditto, magnified highly. (Leydig, iv. 25.)

Fig. 4. Two of the mother-of-pearl organs from the side of the body of *Scopelus humboldti*, seen in reflected light, slightly magnified. (Leydig, vii. 41.)

Fig. 5. Organ from the nasal region of *Ichthyococcus ovatus*, longitudinal section, highly magnified, chiefly to show the entrance of the nerve. (Leydig, vi. 33.)

THE EYE-LIKE ORGANS OF FISHES.

* "With sharpened point that eyeball pierce,
Which 'neath his brow glared lone and fierce."—*Cunnington.*

* To this may be added the case of the decapod crustacean, *Willemoesia* (so named after the late naturalist Willemoes-Suhm, of the Challenger Expedition); one species of this form was dredged in 1,900 fathoms, and the genus is distinguished by having neither eyes nor eye-stalks.

the "Study of Fishes," published last year, the ichthyologist just named speaks thus in the very last paragraph of his book: "Many pelagic and deep-sea fishes are provided with peculiar small round organs of a mother-of-pearl color, distributed in series along the side of the body, especially along the abdomen. Some zoologists consider these organs as accessory eyes, others (and it appears to us with better reason) as luminous organs. They deserve an accurate microscopic examination made on fresh specimens; and their function should be ascertained from observation of the living fishes, especially also with regard to the question, whether or not the luminosity (if such be their function) is subject to the will of the fish."

One of the required conditions has already been fulfilled. Prof. Leydig, of Bonn, has just published a small volume, illustrated by ten octavo plates, in which he deals in great detail with what he has been able to observe in the spirit specimens of ten species, one of which belongs to a genus (*Ichthyococcus*) not examined by Ussow; to this work we shall shortly return. For the moment the prior studies of the Russian naturalist claim our attention.

All, however, agree generally in their account of the arrangement of these spots; ordinarily they extend from the pectoral fins to the tail, and, according to Ussow, they are covered by scales; sometimes they are found in front of the eye (Fig. 2), on the branchiostegal rays, and on some of the adjoining bones; but these anterior spots never exhibit the same striking regularity of arrangement as do those on the abdomen. They vary considerably in the number present, but an average is found to give the astonishing figure of something like three hundred. In *Chauliodus*, Leydig found some thousands of these spots. The most simple seem to be found in *Astronesthes*, a genus which did not come under Prof. Leydig's examination; these have the form of a biconvex lens, which is strongly swollen internally, and has on its outer surface a slight ridge. A layer of connective tissue invests the whole of the organ, and is clothed internally by a layer of brown pigment cells. At the center of the outer surface there is a small circular orifice, from which the deposit of pigment is absent. Just below this orifice there is a lens, which is regarded by Dr. Ussow as exactly comparable to the crystalline lens of many invertebrate animals; and behind this, and between it and the base of the organ, there is a space of some size which is filled with a watery fluid ("aqueous humor"). On the inner wall of this chamber there is a layer of hexagonal plates, transparent and uncolored, exhibiting a very regular concentric arrangement, and containing a protoplasmic mass which is longitudinally striated. These plates are looked upon by the author as representing the retina, and as the end-organs of nerve-fibers.

At first sight there can be no doubt that the general characters of an eye are very well represented, but Prof. Leydig, as we shall shortly show, is able to give a very different explanation of the real meaning of these structures.

Let us, however, next take the much more complicated case of *Stomias* (Fig. 1); here the ellipsoidally-shaped eyes are divisible into two unequal portions, the smaller of which is directed forward, and is applied to the inner surface of the scales, while the other lies among the superficial muscles; the two portions are separated by an extremely delicate partition, and the anterior chamber is filled by an oval and perfectly transparent body, *l*, while the posterior contains a clear and gelatinous substance, *x*, just as in the preceding case of *Astronesthes;* the whole organ is invested by a pigmented layer, *p*, which is only feebly developed on the walls of the anterior chamber, and seems to form, though here we must say we think the resemblance is pressed a little too far, a kind of iris-like diaphragm, *i r*, between the fore and hinder divisions of the organ. It is curious, indeed, that hexagonal transparent cells, apparently made up of prismatic rods, should lie on the inner face of this colored layer, but we must own that they hardly seem to us to have the distinct retinal arrangement which is assumed for them.

Chauliodus is reported to have larger eye-like organs than the two genera already examined; but it is not necessary to deal in detail with this case, for it appears to us that a mere consideration of the account which is given of it lands us in a peculiarly difficult position. The arrangement of this fish's eye is characterized by the presence of a so-called ciliary body, which is described as being comparable to what obtains in the Cephalopoda.

Here it is most necessary to be exact: Are the eyes in question to be compared to those of other vertebrated animals, or are they to be likened to those of the invertebrata?

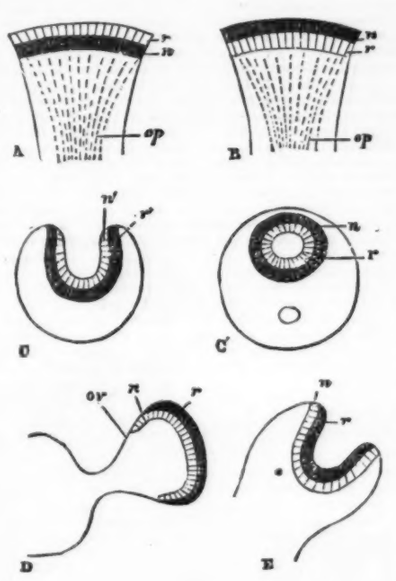
The question is not an unimportant one, for the difference between the two is fundamental and most characteristic, far more important, indeed, than are most of the distinctions that have been insisted on as justifying that most unfortunate division of the animal kingdom into the two great groups of Vertebrata and Invertebrata, which has for long had a disastrous effect on the correct understanding of the real relations to one another of the more highly developed animal forms, but which, we may say in passing, owes its existence neither to the laws laid down by Cuvier after a comprehensive survey of the adult, nor by Von Baer after a close study of the characters of developing animals.

To this distinction let us devote a little consideration. When we compare a section of the eye of any invertebrated animal with that of one of the Vertebrata, we find, with other subordinate differences, of which nothing need be here said, this most important and striking one: in the Vertebrata the "rods and cones," which are the terminal organs of the optic nerve, are placed quite at the back of the eye, are turned away from the light, whereas in the invertebrate, the crayfish, for example, we find the anterior part of the end-organ just below the cornea, and as near to the light as possible; not turned away from it, but toward it.

This important difference in the optic arrangement of the adult of the two groups finds, like many other difficult problems, its explanation in the history of the development of the two kinds of eyes. Both have their prime origin in that outermost layer of the embryo—the *epiblast*—which is the veritable mother of all our sensations. In the invertebrate the only change which occurs is that the cells of this layer become modified and elongated; in the vertebrate their history is more complicated; first, the layer of epiblast dips in below the level of the back of the body, to form the spinal cord and brain; this set of dipped-in cells get cut off from the exterior, and form a tube of epiblast within the body; from the anterior region of this tube there proceeds an outward growth—the optic vesicle—which grows out toward that thickening of the epiblast which forms the cornea. Thus what was originally outside comes to be inside, and when it grows again to the surface, it does so with its constituent parts turned, as it were, inside out.*

* We owe the first distinct literary statement of this history to Mr. F. M. Balfour, LL.D., F.R.S. (See his "Elasmobranch Fishes," p. 169.)

A reference to the subjoined diagrams will perhaps make this difficult point a little clearer. If we take *n* and *r* as representing respectively the layers of nerve-fibers and modified retinal cells, we have in Fig. A a representation of what obtains in the Invertebrata and in B of what is found in the adult Vertebrate; C and C' will show the tube of epiblast, while in D we see the relation of the two layers in the developing optic vesicle, and E shows their position after the "optic cup" is formed.



The bearing of these considerations is not unimportant; it leads us to ask what is really meant when the spots are spoken of as "eye-like organs?" Are they to be compared to those which are found in the head of the fish, or are they only of the same simple origin as the eyes of the Invertebrata? This question does not seem to have been fully treated of by Dr. Ussow. If they are only to be compared to those eyes or eye-like organs of which we have already spoken as existing in *Polyophthalmus*, the question not only unnaturally arises, May they not have some other function? May it not be that their resemblance, such as it is, to the ordinary eye, is only another illustration of that instructive and frequently recurring phenomenon that, under somewhat similar conditions, parts of animals, or, indeed, animals themselves, though of the most diverse origin, come to have very similar appearances in their adult condition? The uninstructed naturalist finds it difficult to believe that the wing of a bird and of a bat are formed on totally different structural arrangements; some crustacea look more like bivalves than crayfishes; and the remarkable outgrowth from the sides of the skull, which distinguishes the tortoises, is to be found, to all appearance, in an African mammal (the rodent *Lophiomys*), and a lowly frog (*Pelobates*), found in Central Europe.

Before suggesting any definite answer to the questions thus raised, we must say a few words about the set of organs to which Dr. Ussow does not ascribe any optic function, although he regards them as really belonging to just the same category. As seen in *Scopelus*, they have the form of a pearl-shaped sac, the wide end of which lies in the tissues, while the narrower end projects a little above the surface; the latter, which is separated from the part below it by a kind of constriction, contains spherical cells, while the lower portion is filled with cells of a polyhedral form; but there is no central cavity, and there is no kind of orifice. This kind of organ the author looks upon as a gland, and in the more complex case of *Maurolicus* there is no doubt that in what he saw there, there is much to support his view. The "glands" are elongated and flask-shaped, surrounded for two-thirds of their length by a pigmented membrane; on the inner face of this there is a layer made up of white fibers, and presenting the appearance of a *tapetum*. Here, again, there is no duct to the gland.

We come now to a species which has been examined both by Dr. Ussow and Prof. Leydig—*Argyropelecus hemigymnus*—and it would be interesting, had we space, to compare what these two naturalists have to say about this form. This curious fish, (Fig. 2), which is here represented as twice its natural size, is found not uncommonly in the Mediterranean, and is remarkable for the great depth of the anterior portion of its body, and the wonderful way in which it narrows off quite suddenly in the region of the tail. In front of the eye there is one spot, and behind it there are two, and six smaller ones are found on the gill-membrane, and six larger ones are found on the throat; by the gill-cleft we see four, the largest on the body, of which two lie in front and two behind the cleft. At the side of the body, and close to the abdominal profile, there are twelve, which decrease in size from before backward; and above these there is a second row of six, all of which are of very much the same size. Between the ventral and anal fins there are again four, and behind the anal fin there are six others, of which the smallest are in the middle. Just in front of the tail fin we find the last quartet of these organs. This gives us fifty-three in all, and as they are paired, we find one hundred and six of these comparatively large spots on the body of this small fish. So much of our account is taken, as is also the illustrating figure, from the description given by Leydig, who would appear to agree so far with Ussow, who says that in this species there are from one hundred to one hundred and ten of these spots; but they differ in the point of covering scales, the presence of which is asserted by Ussow, while Leydig failed to detect their presence. This, however, is not a point of any great importance, and that the more since we know that in the Sternoptychidæ, the family to which this fish belongs, the body is either naked or has only very thin and deciduous scales.

Into the further details, as given by either of the histologists already named, it is impossible for us here to enter; the student who desires to know more of the structural characters will gain a quantity of information from their works.* If we proceed to sum up briefly the general structure of these organs, we find that while Ussow speaks of them as accessory eyes or as glands, Leydig divides them into three groups; (1) eye-like organs, (2) mother-of-pearl-like organs; and (3) luminous organs. Of these the second and third forms would seem to be peculiar to the genus *Scopelus*.

The first set are secular in form and divisible into a bulb, a neck, and an orifice, and this orifice is always directed downward. From what has been already said we know that they have an investment of brown pigment, a layer with a metallic glitter, a gray inner body, and a surrounding lymphatic space. The investment is derived from the general integument of the body, and the pigment granules are contained in the cells of the underlying connective tissue; the metallic layer consists of iridescent plates, rods, or fibers. The gray inner body is divisible into two portions, the hinder and larger of which fills the sac, while the anterior and smaller occupies the narrower neck. The striated appearance of this part, reference to which has already been made, is due, in Leydig's opinion, to the presence of a framework of connective tissue, which sends rays into or forms a network in it; into this gray part there further proceeds a nerve, the fibers of which probably come into connection with the contained cells (see Fig. 5). Ussow, as we know, looks upon these organs as having one of two functions, but never both; Leydig looks at the matter a little differently; without affirming that they are one or the other, he says that whatever they are in *Chauliodus*, to which form Ussow ascribes "accessory eyes," that also must they be in *Gonostoma*, where the Russian naturalist finds "glands;" between the two sets there is, in fine, no essential difference.

The mother-of-pearl organs (Fig. 4) are, as the figure shows, appropriately named; they have, in all cases, an outer brown investment, a metallic layer, a gelatinous internal body formed of connective tissue; they are provided with nerves and blood-vessels and are surrounded by a lymphatic space. The metallic plates are regarded by Ussow as special cells, but Leydig looks upon them as altogether similar to the minute iridescent bodies found on the skin. The gelatinous portion is made up of delicate radiate cells, which give rise to a network, and an intermediate soft substance. No essential difference in structure is presented by the so-called luminous organs.

If we look at the bodies from the point of view suggested by Prof. Leydig, it is impossible not to assent to his conclusion that, whatever they are, they are not sensory in function. At first he was inclined to regard them as belonging to that system of sensory parts which runs down either side of a fish's body, and which is seen from without as a well-marked "lateral line;" but this was a doctrine which a further examination showed him to be utterly untenable.

After these investigations, Leydig proceeds to sum up his objections to the eye-like organs being regarded as presenting anything truly characteristic of the animal eye; and it must be allowed that he makes some of his points with very great force indeed. The examination of *Chauliodus* alone might leave the investigator with a mind inclined toward the explanation given by Ussow, but a clearer view is gained by testing the doctrine by an investigation into the organ of *Argyropelecus;* here (Fig. 3) we see that the "retinal" nerve-cells are connected with the investment formed by the layer of connective tissue; that in fact they are supporting rather than nervous fibers. So again, the brown pigment at first calls to mind an optic organ, but this brown pigment is more widely distributed through the body of the fish, and especially is it developed in the "frontal gland" or epiphysis of the brain, where also it leaves a central, clear, unpigmented spot. Nor is this all—the pigment, as our figure shows, is not laid down continuously, as it is in a choroid, but is scattered at various points. The Bonn histologist carries his merciless criticism yet further; the so-called "lens," which so easily has ascribed to it the refractive function, does not lie in the center but at the edge of the mass which does duty as the vitreous body, and, in addition to its position, its histology prevents us from regarding it as a lens.

One possibility remains; it may be argued that the bodies in question are not to be compared to the ordinary vertebrate eye, but that they are nevertheless terminal sensory organs affected by light; but here, unfortunately, we come upon what is the greatest difficulty of all, the "pupil," the "lens," and the "vitreous body" are not turned upward to the light, but so long as the fish is swimming they look downward into the deep; and in the case of *Chauliodus* are developed also on the membrane that lines the cavity of the mouth.

After this piece of destructive criticism, it remains for Prof. Leydig to make some suggestion as to what the organs in question can best be compared with. He is of opinion that they bear the closest resemblance to the electric or "pseudoelectric" organs of other fishes, and he brings many points to strengthen his position. Before we come to any judgment on the matter ourselves, it will be necessary to recall to mind the general structure of an electric organ. These, however much they may vary in details and in their position on the fish that possesses them, always present the following points: They are richly supplied with nerves, they are surrounded by a layer of connective tissue, which gives rise to a number of "alveolar" chambers filled with a gelatinous substance. In such a form as the electric eel (*Gymnotus*), we find that on the face of each partition which looks backward, there is a thin homogeneous layer, which is apparently formed of mucous tissue, and on the opposite face, or that which looks forward, there is a much thicker layer. The nerves passing to and breaking up in this plate, give rise to the electric organ.

When this account is compared with the description that has already been given of the mother-of-pearl organ, we see at once a very considerable resemblance; in both there is a contained mass of gelatinous tissue, in both the same network of connective tissue, and in both nerve-fibers of very much the same character. Nor is this all; in some species, *e.g.*, *Scopelus rissoi*, there is a spindle-shaped cord or plate, which is formed of extremely delicate granules, and this the author is inclined to regard as comparable to the special *electric plate*. With these essential resemblances, the form is a point of very secondary importance; but even with regard to it Prof. Leydig is ready with an explanation. The rounded form of the mother-of-pearl organs is due to their position on the surface of the body; like the electric organs they would probably become angulated, if they were massed together to form a single body.

Whether they really have the power of developing electricity is a problem that cannot yet be solved; but the question has been put, and it becomes the duty of such naturali-

* Ussow, M., "Ueber den Bau der sogenannten augenähnlichen Flecken einiger Knochenfische." Bull Soc., Moscow, liv. 1879. Pp. 79-115, 4 Pls. Leydig, F., "Die augenähnliche Organe der Fische," Bonn, 1881. Pp. 100, 10 Pls.

ists as may have the opportunity to do their best to resolve it.

Nor are we yet in a position to speak dogmatically as to their functions as illuminating organs; no definite phosphorescent organ has ever yet been examined which presented any other contents than fatty or oily matter,* and the cases are rare in which the part which is phosphorescent has not some other and more important function also; where this is not so—as in the instance of the phosphorescent insects—we find, and it is very curious to note this, that the distinguished histologist, Kölliker, of Würzburg, suggested, nearly a quarter of a century ago, that the luminous organs are essentially nervous and present the nearest resemblance to the electrical organs of fishes. This point is not noticed by Leydig, but it would be curious if it should finally turn out that the organs he has been describing with such care are intermediate between the other two sets. Even if not phosphorescent, it still remains possible that these creatures add to the feeble light of great ocean-depths by reflecting the light that falls on these eye-like organs. We all know how a cat's eye "shines" in the dark, and most of us, it is to be hoped, know that this is no case of phosphorescence, but that there is a thick layer of wavy fibrous tissue lining the inner face of the eye which reflects the light; reflecting it, by the way, not for the purpose of illuminating the neighborhood of a nocturnal beast of prey, but reflecting it for the purpose of as many rays as possible passing to the retina. In some of the fishes of which we have made mention, a somewhat similar tapetum has been found, and it is quite possible that that layer does act as a reflector in one of the worst illuminated regions of the habitable globe.

For ourselves, we are inclined to think that the relations of these organs to those with electric properties in other fishes is the most reasonable that has yet been advanced, they may have a secondary illuminating function of some kind, but it was not the necessity for this that first gave rise to their formation. If we assume the correctness of Prof. Leydig's explanation, we have before us a very interesting example of the way in which scientific hypotheses become theories. An obvious external resemblance to secondary eyes led the first naturalist who studied them closely to look on them as accessory organs of sight; a closer and more detailed investigation has shown that this resemblance is purely artificial, and an appeal is now made not to a seeming likeness, but to a more deep seated similarity, to one that depends not on the position of rounded fibrous bodies or to a peculiar arrangement of pigment; but to one, in fine, that depends on community of structure, the first and best implement in any investigation into living objects, and the one that, side by side with the history of development, is the only criterion to which the judicious naturalist finds it wise or expedient to appeal.—*Popular Science Review.*

* On this point the student is especially to be referred to the various papers of the late Prof. Panceri; for the phosphorescence of fishes, consult Panceri in "Zool. Record" for the year 1871.

[FOR THE SCIENTIFIC AMERICAN.]

RIVERS WITH HIGH BANKS ON ONE SIDE AND LOW BANKS ON THE OTHER SIDE: WHAT IS THE CAUSE?

IT has been observed in Europe and Asia and in the lowlands of the Atlantic border of the United States, that the western banks of many rivers and streams are considerably higher than are their eastern banks respectively; especially is that the case where the rivers are large, the deposits earthy, and the pitch of the water small and in the direction of the stream. And, to account for this phenomenon, it is claimed that, *owing to the eastward rotation of the earth*, the western banks, in a sense, are pushed harder against the western sides of those rivers, etc., than is the case with their respective eastern sides: hence the greater steepness of the western over that of the eastern banks of rivers, etc.; because the waters cut more forcibly into them, the undermined deposits fall, and these banks, in consequence, are steeper than are the opposite ones. So some think.

If it be admitted that the above hypothesis is true, then the next thing in order to be looked for is a retardation of the earth's rotary motion: for if it be the fact that the earth, by virtue of her rotation eastwardly, throws herself in a manner, though ever so slightly, against the western sides of oceans, seas, and rivers, the result will be, that, in the end, be it ever so far hence, her rotary motion will be entirely suspended: a thing altogether without parallel in any body of the solar system, and absolutely without foundation in regard to the earth. I account for the phenomenon above given by a different order of action in nature, thus:

It is a world-wide known fact that the earth is ever turning one side of herself, in a sense, toward the sun, and at the same time turning away her other side; the darkened, bedewed night-side is ever turning toward the sun, meeting and welcoming his rising, in the east; while the heated, dried-up day-side is ever bidding him an evening adieu in the west. What it is that gives to the early-morning side of the earth a more powerfully attractive hold of the sun than that of her evening side is not altogether understood by me. But the actual working of the solar terrestrial machine convinces me, at least, clearly that the earth has not been set in rotary motion by a single impulse, at first, but that she is continually being pulled round, as with a belt, by extra attraction *in*, say, her *morning side*.

Now, then, to explain how it is that the western banks of many rivers and streams are higher and steeper than those on their eastern sides, we have only to remember that, somehow, the particles of matter, especially *on* and *near the surface of the earth*, are more heavily charged with attraction than are those dried and heated ones on her opposite side. The consequence of this is, that the looser particles of dust and earth on the eastern banks of rivers, etc., are drawn more or less every morning *toward the sun*, and *away from the streams*, etc., while, on the other hand, the looser particles of matter are drawn *off* the face of the western banks, in which case they *fall down* toward or into the rivers, and are carried away; at the same time other particles are drawn from the higher grounds on the western sides of the rivers, all the time adding to, and keeping up, the height of those banks.

It is by this same means of moving or attracting bodies toward the sun that the equator of the earth has been built up to that it is. And not only is it so in regard to the earth: it is the case in all the planets. These equators have been severally built up I contend, not by any force *in* them, throwing off, or from the center, as some say, like a grindstone; but by the force *outside* of them, rolling them round as with a belt. Supposing a planet to be absolutely round, composed of the same sort of material all through, and every particle to possess the same exact attractive force: it could not turn on an axis—it could not rotate. There must, some part of it, be higher than the other parts, or some portion of it more attracting than the others; and it must have a mass sufficient, when once set in rotary motion, to overcome the counter attraction of the sun, else it will swing to and fro, like a pendulum. We have an instance of that kind in the moon. It is held, so to speak, by its most attracting side, to the earth, and, in approaching the sun, this side is drawn round a little toward the sun, and a reverse motion in the moon, amounting to the same thing, is seen to take place after she has passed the sun and begun anew her orbit round the earth.) Now I say, as I said before, it is this force of extra attraction in some external or outside part or parts of a planet's body that gives it rotation; and it is the same process which reduces the eastern banks of rivers and heightens their western banks, that the equators of all the planets have been built up by. And the best proofs of this fact that I know of, or can think of, are to be found in Jupiter and Saturn. Their equators are high and in keeping with their vast dimensions; and the consequent action of attraction on them severally is, that the larger of the two rolls round his axis in less than half the time of the earth, (9h. 55m. 26s.), and the other (Saturn) in a few minutes more (10h. 29m. 17s.). This shows the attractive *pull*, not the centrifugal *throw out*, working on those bodies and building up their equators. In them it is shown that the longer the lever (it matters not how much has to be turned), the quicker that mass wheels round when old Sol takes hold on it, or it takes hold on Sol. And just so will it be in reference to the earth. In proportion as her equator is built up over and above the height of her poles, and as she acquires mass, will her rotary motion increase in velocity. And judging from the facts that the earth is constantly acquiring more or less matter (meteors, etc.), and that Jupiter, etc., though both are vastly larger than the earth, rotate in far less than half her time, I contend that the earth is not slowing in rotation; that she cannot be retarded by any such cause as *butting*, in a measure, against oceans, seas, and rivers; that she has not been rotated, at first, by a single impulse, but that she is rotated every instant as with a powerful belt; and that the hypothesis which ascribes more pressure of the ground on one side of oceans, seas, etc., than on their other side, respectively, is untenable. This hypothesis accounts for a *high* and a *low* bank, to rivers, streams, etc., but the other does not!

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THE PAMIR.

AT a recent meeting of the Russian Geographical Society, M. Severtzov gave some of the results of his recent visit to the Pamir Mountains, in which he corrects in many important respects the generally received conceptions as to the nature and structure of that range. The Pamir, he finds, is no tableland, and has to the height of some 12,000 ft. no steppe region. There are valleys along the rivers up to a height of 14,000 ft., but the widest is only 20 versts, and a wider surface is not to be found.

This peculiar feature of the Pamir has in common with the Tien Shan and Tibet, where similar valleys of narrow width at considerable heights are found. Real, lofty plateaus are not to be found on the Pamir. The mountains rise in lofty ridges to 6,000 ft. and 7,000 ft. above the valleys. The absolute height of the mountains of the Pamir reaches often to 19,000 ft., and three groups of great altitude reach as high as 24,000 ft. But these elevations do not alter the generally symmetrical character of the Inner Pamir.

Another characteristic feature of the Pamir Mountain region is that the mountain lines stretch in the direction of the meridian, and seldom strike out at right angles.

In this respect the Southern Pamir resembles the mountains of Tibet, whereas in the Tien-Shan the tendency is to parallel ranges. In geological character, also, the Pamir seems to differ considerably from the Tien-Shan. M. Severtzov recognizes in the lower strata evidence of the ocean gulf which once separated the Pamir from the Tien Shan.

Both are independent mountain systems, even if the elevation of the ground between them is not less than 10,000 ft. The oldest formations are found in the Inner Pamir, which, in this respect, is regarded as the groundwork of the system. Evidence was obtained to show that the elevation of this range is still going on. In the course of 12,000 years it has risen 600 ft.

THE MUCK DELUSION.

THE delusion which prevailed twenty and more years ago, regarding the manurial value of what is known as *muck*, has lost some of its force, but it still exists among farmers, especially those new in the industry. Among the newspapers "the great value of muck to farmers" is a standing text from which a labored sermon is preached once or twice a year. Twenty-five or thirty years ago, a little book was published by Dr. Dana, a Lowell chemist employed in one of the dyeing establishments of that city, which supplies the material for these sermons, and will continue to do so perhaps for the next half century. That book is full of errors and absurdities, and has led more farmers into incurring serious expenditures without corresponding returns than any book on manure ever written. The fallacy of muck consists in the error of regarding it as manure, or a substance which turns spontaneously into manure without cost to the farmer. The term "muck" is usually applied to the dark, wet, unctuous product of low meadows, and the black mud from the bed of marshy lakes and frog ponds. The material varies greatly in physical character and chemical composition, no two specimens taken from different localities being alike. The advocates of muck, or the writers upon the subject, have but little to say in regard to these important modifications; with them, muck is muck, whether it be made up of black sand or of vegetable *débris* in a stage of partial decomposition. Now, muck is not a manure, whether it comes from a peat meadow or from the silicious deposits in the bed of a dried-up frog pond. It is not manure, and moreover it cannot be made into plant food by any expense of time and labor which the farmer can afford to apply to it. For a period of twenty-five years we have given much attention to muck, and have instituted a series of experiments with it in the laboratory and in the field, in all the forms and modifications in which it is found upon New England farms, and we say now, what we have often said before: it is a material which in general farmers cannot afford to spend much time upon. If it had absolute or potential value as manure, the wet mud from meadows cannot be hauled long distances with profit, but it has not under any circumstances manurial value. The peat of bogs, as freshly taken out, averages of water fully ninety per cent., and a load of this of two thousand pounds gives but a couple of hundred pounds of dry humus at the barn. If through inexperience or want of close observation a farmer backs up his cart to a mud hole, dry in summer, he loads into it a substance which is usually valueless: we have seen many farmers hard at work, after haying, upon a deposit of this nature, and have often had the pleasure of saving them much toil, by proving on the spot the worthlessness of the substance they were endeavoring to utilize. A substance holding seventy per cent of clear sand and thirty per cent. of black mould is "one well calculated to deceive." It looks rich, and is tempting to many who desire to increase their manurial resources. A little of this material put into a tumbler and stirred up with much water at once reveals itself, as the sand settles to the bottom and the black vegetable matter floats above.

The true value of muck is well understood among chemists, or at least it ought to be. It really holds no available plant food, although it contains some nitrogen and carbonaceous elements. These do not exist in it in available forms, and cannot be brought into that state at a cost which will under ordinary conditions warrant transportation and manipulation. Muck has a certain value as an absorbent of liquid manure, and it may pay to procure and dry it such purposes; but to meet this want it must be convenient to the barn, and of good quantity. Farmers cannot afford to be deluded or led astray on any point, and therefore, it is important that the true value of what is called muck should be understood.—*Boston Jour. of Chem.*

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